AUGUST 13, 1961

MACHINE DESIGN

A PENTON PUBLICATION — BIWEE

Pumps and Motors

Contents, Page 5

MR. STEVENS RICE
UNIVERSITY MICROFILMS
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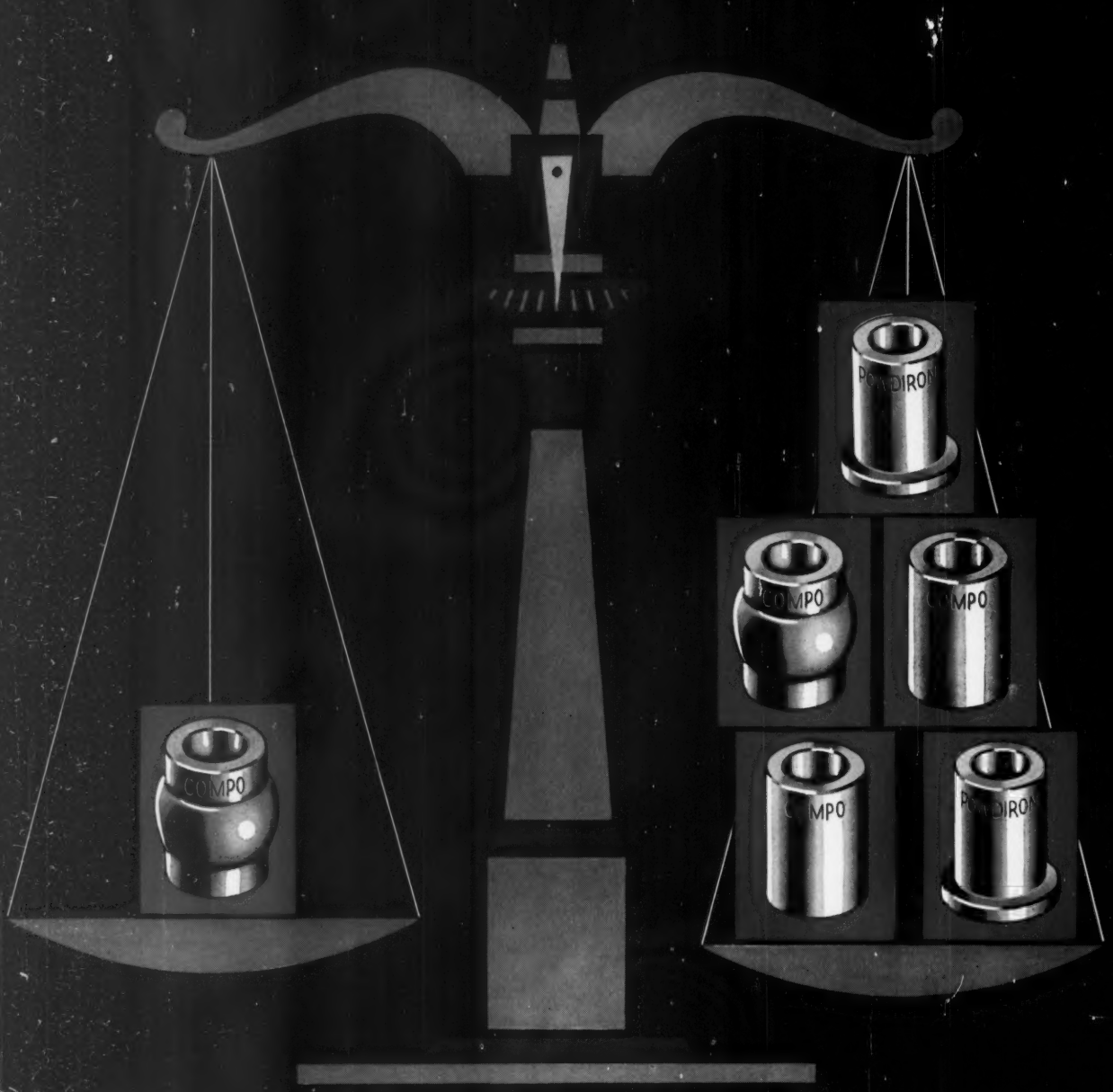
ANN ARBOR, MICH.

FARNSWORTH



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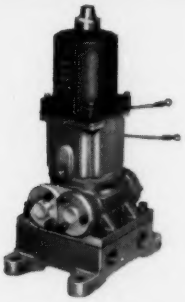
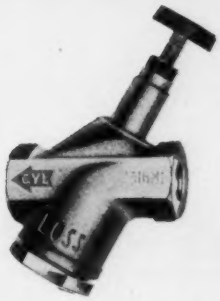
The stock shelves at **Ross** include more different air valves than any other stock shelves in the valve world

Do you know these air controls by Ross ?



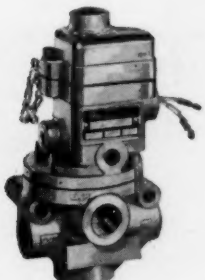
50 Million Cycles in Tests

Ross Goldmodel. A lightning fast, base mounted valve with its solenoid immersed in oil to run cool for long, long life. Full JIC. 3-way, 4-way and 4-way 5 port models. ¼" through 1¼".



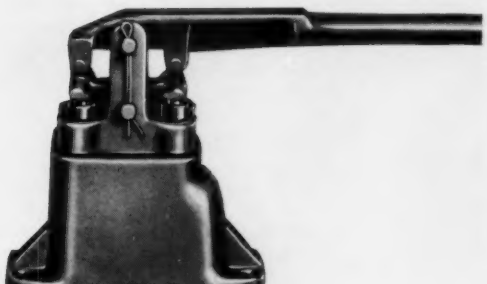
Control Cylinder Speed

Speed Control Valve. The adjustment screw directs air through an orifice that's engineered to give fine shadings of control at either high or low flow rates. ¼" through 1¼".



Does a Big Valve's Work

"Headline Series". Highest capacity valve-size for valve-size of any valve we've seen. Use a smaller, economical inline valve to do a bigger, more expensive valve's work. Fast. S-way, 3-way, 4-way. ¼" through 1½".



Especially for Tough Duty

Ross #100 series. Rough, tough jobs call for this valve which can pass most dirt and foreign matter with no trouble. Few moving parts and short poppet travel makes it especially wear resistant.

FOR OTHER ROSS VALVES SEE SWEET'S PRODUCT DESIGN FILE

The most complete line of air controls in the world

ROSS OPERATING VALVE COMPANY

109 E. GOLDEN GATE • DETROIT, MICHIGAN

Circle 204 on Page 19

another torture test for leaded alloy

This guide bushing is a much abused part in a pneumatic rock drill—subjected to severe shock loads and a shattering type of vibrational stress. It is machined from a bar of lead-treated* Aristoloy 8620, carburized and hardened to a 58-63 Rockwell "C". When GARDNER-DENVER switched to lead-treated steel, they happily discovered production jumped 42%. Feed rates, drilling, turning, forming, boring, and cut-off operations could also be increased. Tool life was extended 20 pieces between grinds.

For complete information about how you can get alloy steel strength in free-machining steel, call your nearest Copperweld representative. Or write for Leaded Steels Catalog and Products & Facilities Catalog.

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DIVISION OF
COPPERWELD
STEEL COMPANY

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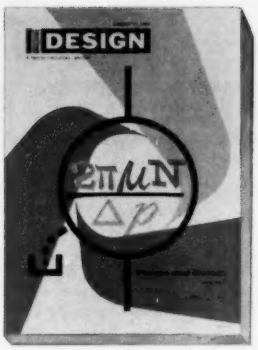

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THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

August 17, 1961
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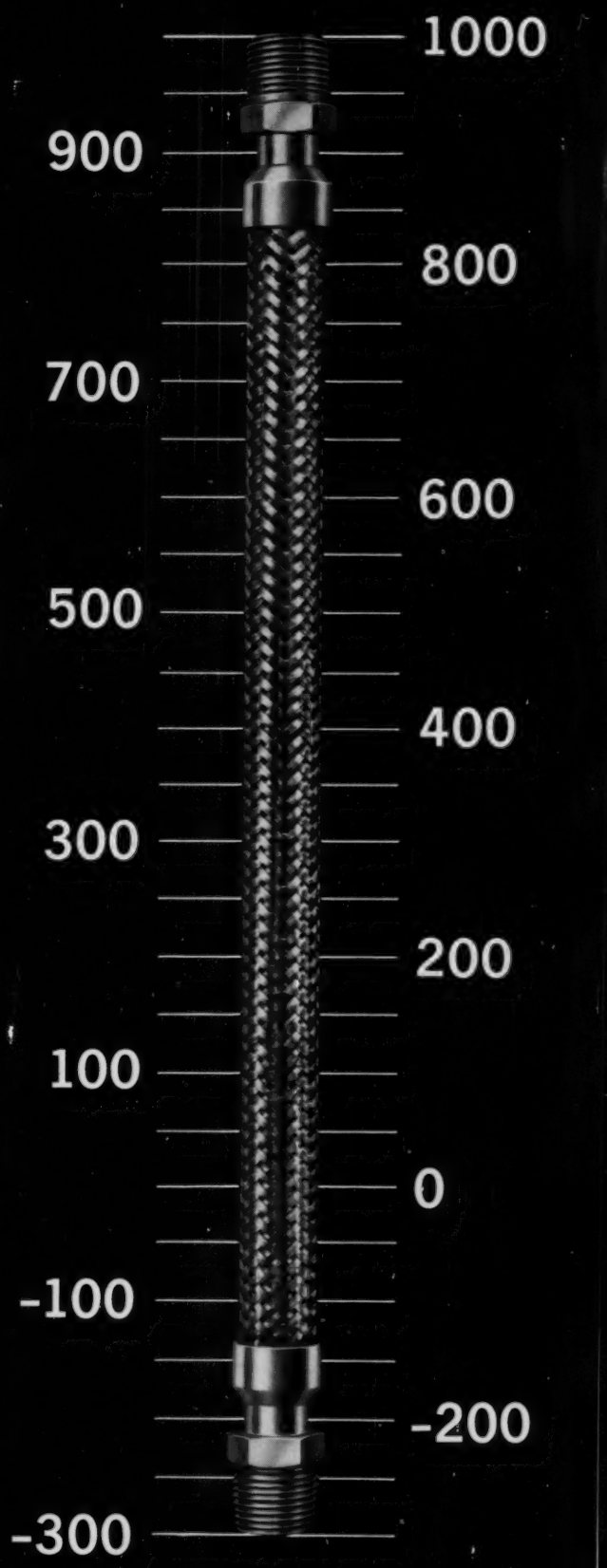

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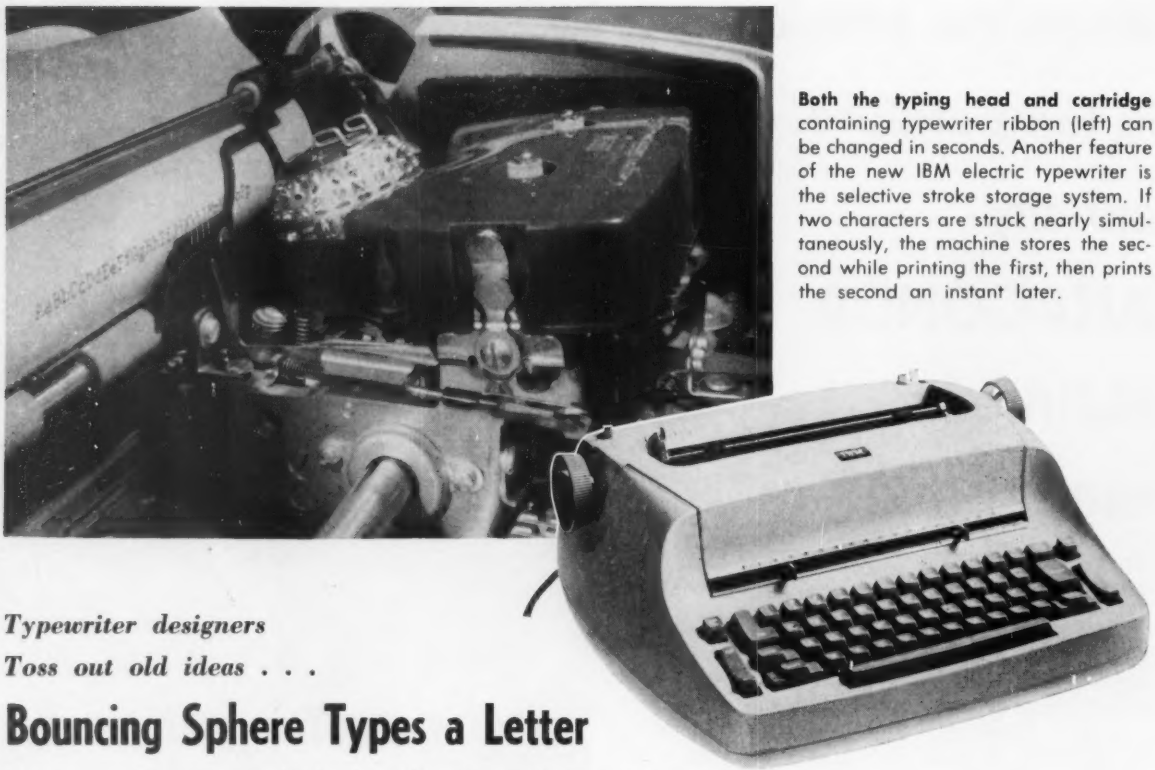


Both the typing head and cartridge containing typewriter ribbon (left) can be changed in seconds. Another feature of the new IBM electric typewriter is the selective stroke storage system. If two characters are struck nearly simultaneously, the machine stores the second while printing the first, then prints the second an instant later.

Typewriter designers

Toss out old ideas . . .

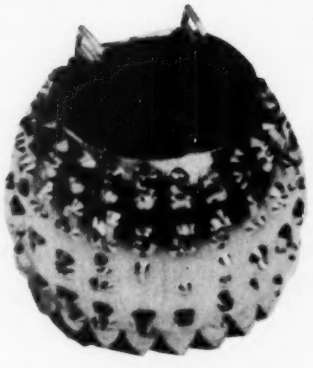
Bouncing Sphere Types a Letter

LEXINGTON, KY.—A new kind of electric typewriter has no type bars or movable carriage. A sphere-shaped head yaws and rotates while moving horizontally to print a single line. On the sphere, four rows of eleven numbers, symbols, and letters are grouped in each of two hemispheres that contain upper and lower-case characters respectively.

Developed by the Electric Typewriter Div., International Business Machines Corp., the new typewriter resulted from an entirely new design approach. By eliminating type bars and movable carriage, IBM engineers have come up with a lighter machine that requires less desk space, reduces vibration, and eliminates carriage-return jolt. The typing head can be quickly changed if a different style of type is desired, and the ribbon (contained in a two-spool cartridge that snaps on the same carrier as the head) does not require rewinding before it is changed. Both type style and ribbon color can be altered in seconds.

The printing head, a $1\frac{3}{8}$ in. diam truncated sphere, is mounted on a head-and-rocker assembly which, in turn, is mounted on a small carrier. The carrier moves to the right as the machine is typing. When the operator touches a key, a system of linkages and pulleys rapidly tilts and rotates the head to bring the proper character into position for printing. The head rocks against the ribbon and paper at a speed of $15\frac{1}{2}$ characters per sec.

The sphere has two axes of rotation—one through the poles, the other through the equator. Motions about the axes occur simultaneously as a character is positioned. From a home position, the sphere rotates a maximum of 82 degrees about its axis, and 50 degrees about the equator. When the shift key is operated, the head spins 180 degrees to a new home position in the upper-case hemisphere.



Snap-on typing heads come in six type faces, including a script. Ribbon cartridges house 18 yd of nylon ribbon in an enclosed plastic case. For the first time, the typist can change both type face and ribbon color without removing the letter or manuscript page from the machine. Ribbons come in seven colors in addition to black, bicolor, and plate-writing types.

...Fluid Power NEWS

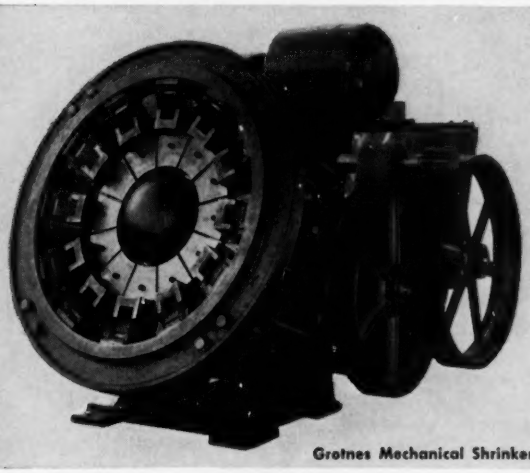
OILGEAR 40 Years of Fluid Power

Report No. 11,601 From Oilgear Application-Engineering Files

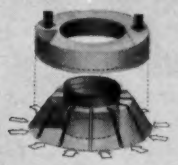
HOW OILGEAR HEAVY-DUTY POWER-PAKS EXTENDED WORKING RANGE OF GROTNES MACHINES

CUSTOMER: *The Grotnes Machine Works, Chicago, Illinois.*

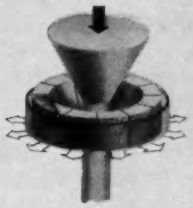
DATA: Grotnes expanders and shrinkers are used for forming and sizing sheet metal parts and heavy rings to tolerances of ±.002″ without heat, machining, or waste. Any continuous cross-section part (square, round, oval, etc.) is expanded over jaws mounted in a slotted table. The jaws are moved radially outward by a drawbar-actuated cone, forming or sizing the part by stressing the metal beyond its yield point to induce a permanent set. In shrinking, the jaws are forced inward against the part by a tapered ring or toggle links. World-wide acceptance of this unique method has led to industrial requests for Grotnes machines with greater working forces, longer strokes, more uniform power than are practical or possible with mechanical drives using gear trains and crankshafts.



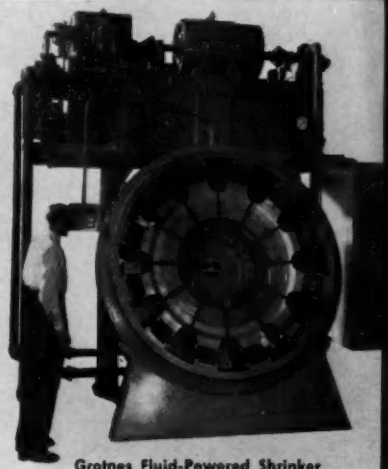
Grotnes Mechanical Shrinker



Grotnes Shrinking Method



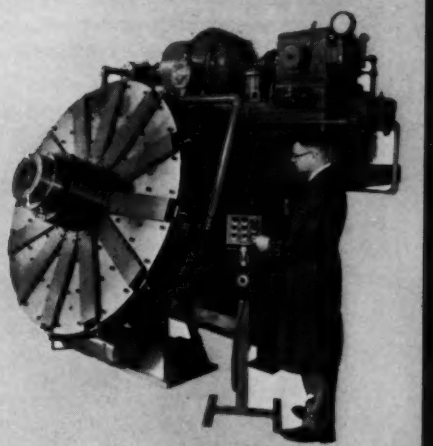
Grotnes Expanding Method



Grotnes Fluid-Powered Shrinker

SOLUTION: Shown above are two Grotnes shrinkers—one mechanically powered, the other Oilgear Fluid Powered for greater tonnage, longer stroke, more uniform power. Note the neat appearance of this new unit with its convenient, simple panel for precise, automatic control. Shown, right, is one of a new line of Grotnes expanders designed specifically for Fluid Power operation. Capacities range up to 1,580 tons on the new expanders; to 800 tons on the new shrinkers—based on 3,000 psi pressure provided by Oilgear application-engineered Heavy-Duty Power-Paks. Performance and control on these new, larger machines has been so outstanding that Grotnes is now equipping expanders as small as 25 tons drawbar pull with Oilgear Power-Paks. This is just one example of Oilgear cooperation and teamwork with designers and builders of machines for industry. An Oilgear Power-Pak is more than just a clean-appearing, unitized assembly of a pump, motor, reservoir, valves and controls . . . it is an efficient, leaktight, easy-to-install, Heavy-Duty Fluid Power system based on over 35 years of pioneering-engineering-knowledge that provides: automatic, electric power conservation; precision-controlled pressures, positions, cycle times; dependable operation; unit responsibility for the entire power system. Because of Oilgear's long reputation for dependable, trouble-free Fluid Power for virtually any application, Oilgear has become a name that all industry trusts . . . and uses.

For practical solutions to your linear or rotary drive and control problems, call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to:



Grotnes Fluid-Powered Expander

Oilgear application-engineered Power-Paks are also used extensively on hotplate, plywood, pulp-baling, injection molding, extruding, forming, and other presses. Oilgear rotary drive and control systems are equally well accepted in virtually every field of manufacturing and processing. For accurately controlled linear or rotary power . . . for the lowest cost per year . . . check with Oilgear!

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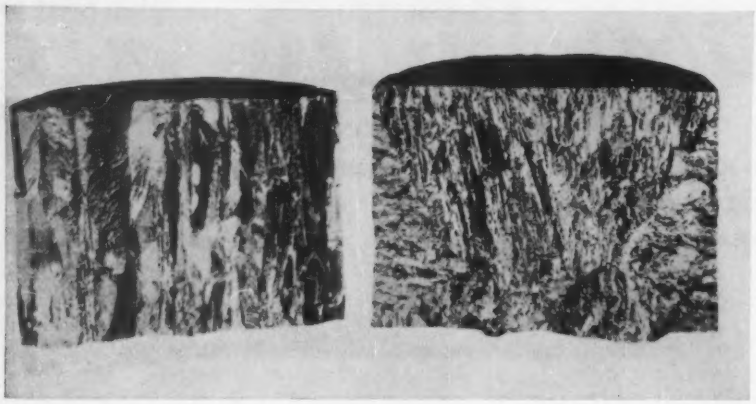

Grains line up through the entire cross section of the powerful new magnet material (left). The orientation is made possible by a proprietary process developed by USM&A. Because grain "highways" uniformly penetrate the casting, there are virtually no boundaries to cause energy losses. Alnico V-DG magnet (right) does not show this uniformity of grain pattern.

New Strength for Permanent Magnets

BLOOMFIELD, N. J.—A new permanent-magnet material, Alnicus, produces a nominal energy product of 7.5 million gauss-oersteds, 1 million more than the best of the commercial Alnico alloys. Developed by U. S. Magnet & Alloy Corp., the material is already being used in production magnets.

"The high-energy material is the most powerful anisotropic magnet material available today; it produces more magnetic energy per unit volume or weight than any other material on the market for production magnets," according to Mr. S. Weimersheimer, president of USM&A. Directional solidification of crystal formations in permanent magnets may now be achieved in sizes and shapes never before possible.

Because of its capacity to produce high power in virtually any magnet configuration, and because it makes size reductions possible, Alnicus should find wide application. Mr. Weimersheimer claims it "broadens the scope of magnet use in consumer products and industrial and defense applications" by offering a new latitude and flexibility to selection of magnetic material for design.

Thermionic Generator Burns Propane

Flame-heated thermionic gererator burns a propane-air mixture to produce temperatures high enough for direct conversion of heat to electricity. Developed by Atomics International Div., North American Aviation Inc., Canoga Park, Calif., the device is the first actually designed to use ordinary fuels (GE has one that will work on fossil fuels, but it wasn't specifically designed for them). The flame, confined to a furnace section, heats one electrode to 2800 F, boiling electrons off it to produce a current. Al spokesmen say the generator may eventually find its way into central-station powerplants. It could improve efficiency by 20 per cent. Operating temperatures are so high that its waste heat could drive conventional turbine-generator systems.

Topics

No waiting is a feature of new Westinghouse television sets, which produce both picture and sound within a second after they are turned on. The quick start is made possible by keeping the tubes warm. Electricity used for this purpose costs only a few cents a week, says Westinghouse, and tubes last longer because they are not subjected to sudden temperature changes.

• • •

Sun so hot I froze to death: Cooling is the "most logical" application for solar energy, according to Louis Lopez of the University of Florida's Mechanical Engineering Dept. The greatest amount of solar energy is available in summer, when the most cooling is required. Mr. Lopez says solar cells and thermoelectric refrigeration are promising, but the absorption cycle is the only system useable at present.

• • •

Newest newsy is a vending machine, being tried out in New York City, which sells six different magazines. No browsing.

• • •

Self-starting cigarettes will have coated ends which, when drawn across an abrasive surface, will ignite. American Machine & Foundry Co. is to design and build machinery for Continental Tobacco Co. Inc., which will produce the self-lighting cigarettes.

• • •

Shopping with the aid of IBM, the customer picks up a card (from a stack placed next to each item) instead of the merchandise. Cards, presented to a cashier, are put through a machine which prints an invoice in triplicate. One copy goes to the stockroom where merchandise is collected quickly and delivered to a pickup window.

• • •

Atomic energy in the Arctic provides weather data from an area where it is impossible to send a human weatherman. Powered by an isotope of strontium-90, a weather station located on an island about 15 deg latitude below the North Pole will operate for about two years. The station and power source are housed in a cylindrical, insulated 8-ft long container, sunk to a depth of about 5 ft in the frozen ground. Data gathered by an anemometer, a thermometer, and a barometer will be fed into a data processing system then transmitted by radio every three hours to permanent weather facilities farther south.

Want to be an Executive?

Management is actively looking for engineers who have the desire and ability to become administrators

by
James M. Jenks

In a sense, this is the golden age for engineers. Once buried in corporate obscurity, many of them have emerged today as likely heirs apparent to the big jobs — and the big rewards — of business and industry. One impressive indication of this growth is that money spent in research and development over the past fifteen years has increased six-fold.

Despite this stepped-up activity, however, the once disorganized scramble for engineers seems to have ended . . . at least temporarily. And perhaps it's a good thing. Actually, the more perceptive engineers had always realized that unusually high starting salaries were often illusory. The gap between money being offered beginners and the incomes of experienced men was narrowing rapidly. Further, more and more thinking technical men concluded that even top engineering salaries are low when compared with the remuneration of highly placed general executives.

A Plan to Help the Engineer Succeed

Happily, there is a route to increased incomes that is satisfying to both engineer and company alike. This route leads into *management*. It is no easy road but the rewards are great for those willing and able to follow it.

In the vast, complicated world of business the engineer has much to learn. As a manager his duties will bring him into contact with accountants and buyers, advertising men and salesmen, lawyers and other executives. A strange new set of circumstances confronts him. He must gain confidences and be understanding, learn and instruct, be sympathetic, paternal or commanding as conditions require . . . and all in the midst of a business organization about which his knowledge is limited.

Actually, it comes down to this: To succeed as a business executive, the engineer must learn the art of making decisions quickly and accurately. And this ability is, of course, directly dependent upon knowledge. The "principles" of business—while not as scientific and inexorable as those of engineering—are no less important . . . no less essential to efficient procedure.

For nearly fifty years, the Alexander Hamilton Institute has specialized in bringing this knowledge to mature men—at home in their spare time.

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27A

Circle 208 on Page 19

Safety Device Heckles Sleepy Drivers

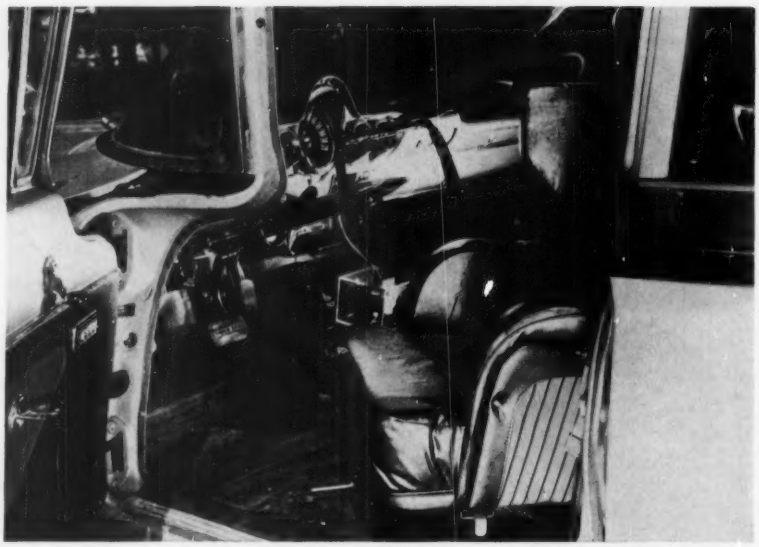
HOPKINTON, MASS.—Alert-O-Matic, an electromechanical device perfected by the Liberty Mutual Insurance Co., solves the problem of road fatigue by keeping the automobile driver wide awake. Light and compact, it can be wired into any car or truck.

In operation, the device flashes light signals at a driver at predetermined intervals. The driver need not respond immediately; the instrument gives him five seconds before taking further action.

If this first stimulus fails, the car's horn starts to blow. This usually rouses a dozing driver, and it also warns other cars.

After three seconds of horn blowing, the device sets off a third signal. Severe jolts, caused by the ignition being switched off and on in rapid succession, are induced in the car. If this fails to wake up the driver, the ignition shuts off after five seconds, stopping the car.

Once alerted, the driver can signal he is awake during any part of the warning cycle by tapping the horn ring, automatically resetting the alarm. The warning light again starts to flash 60 seconds later.



Mounted in Survival Car II (MD, April 27, 1961, p. 6), the Alert-O-Matic signaling device has been field tested for many thousands of miles of city and country driving. The unit is housed in the plastic box located over the transmission hump. It is one of the 24 safety features now incorporated in the car. Similar units have been provided in three additional Survival Cars that are touring the country, and field reports indicate no driver stays sleepy long when watched by the device. Liberty Mutual Insurance Co. developed the alarm unit as part of its continuous program to cut down the highway deaths (38,200 occured in 1960). While part of the program involves educating drivers, the company is also working on improvements in automotive equipment in an effort to combat motor-vehicle accidents.

Solar Cell Matched to Space Sunlight

LOS ANGELES—The blue space solar cell, a new type developed by Hoffman Electronics Corp., will reportedly deliver more electrical power to satellite instruments than any other cell of the same size. And it will have a longer useful life in space.

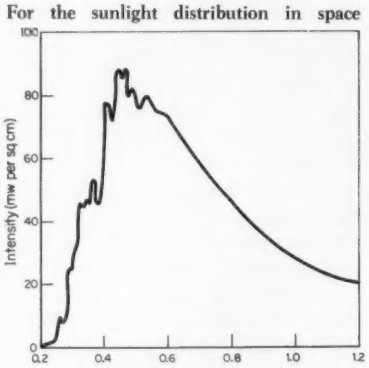
First solar cell tailored to wavelength and intensity characteristics of sunlight in outer space, the device outperforms standard cells in the blue (short-wave) end of the spectrum. By the time sunlight reaches the earth, clouds, water vapor, air, and contaminants have filtered out a lot of the shorter wavelengths, but in space, the blues are stronger than the reds.

The response of the cell is 10 per cent better than that of standard types in the 0.45-0.50 micron region —the highest-energy of the Sun's spectrum. Total output exceeds that of other cells by at least 15 per cent. With older cells, the designer could count on about 8.5 watts per sq ft of panel surface. Now, the same area will deliver 9.5-10 watts reliably.

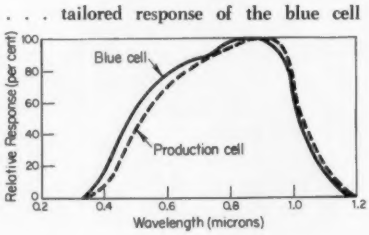
The blue cell is expected to have longer life because it has a thinner diffused surface. Past investigations showed shallower junctions have higher nuclear-radiation resistance, and shallow junctions had to be developed for the blue cell. Moving the active junction closer to the surface altered cell response so that the shorter wavelengths of blue light could make a greater contribution to total energy conversion.

Lockheed Aircraft Corp. pioneered space-sunlight studies several years ago. Since then, Hoffman researchers perfected a simulator that accurately duplicates intensities and wavelengths of this light.

For the sunlight distribution in space



. . . tailored response of the blue cell



TO THE CREATIVE DESIGNER...

how many viewpoints must you reflect?

As if designing equipment in these competitive days wasn't enough, today's designers must view their creations through many eyes... *management, production, purchasing, sales, service*... and reflect the desires of each of these groups. And, most important, there's the customer!

The designer can be a specialist in many things, but it takes too much time to be an expert in everything affecting equipment design.

That's why efficiency-conscious designers are turning to CHAIN Belt for specialized service in power drive and conveyor chains.

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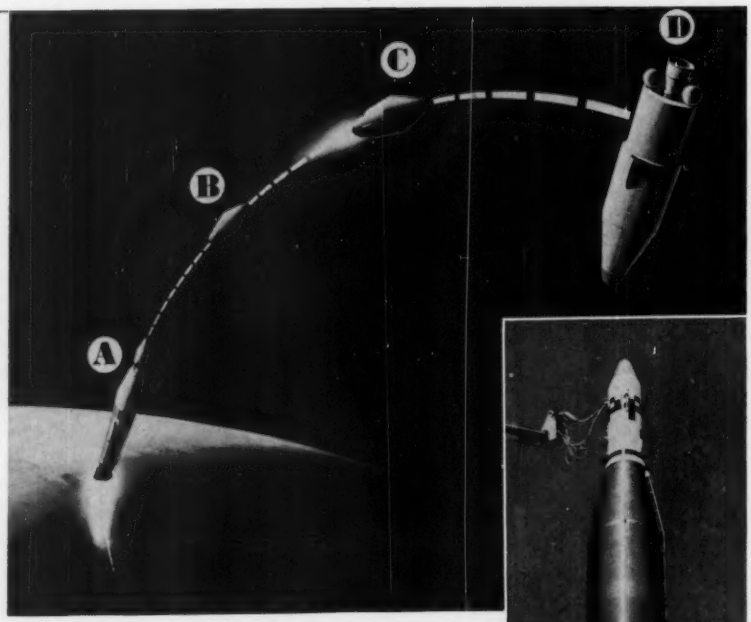
Circle 209 on Page 19

Midas Starts Its Checkout

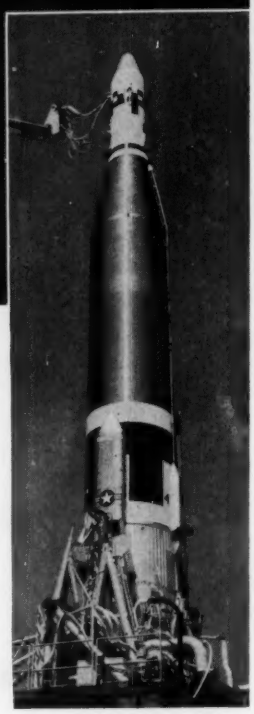
SUNNYVALE, CALIF. — Designed to monitor unfriendly missile-launching sites, Midas III is now presumed under test: It's reporting American missile firings. Orbited last month, the satellite is the first of more than six that will make up the earliest possible warning system scheduled to be operating about 1963. Midas I didn't orbit, and while Midas II did, it immediately suffered telemetry-equipment failure that put it out of action.

Still in the research and development stage, Midas systems use the Agena-B vehicle, developed by Lockheed Missiles and Space Co., to carry the payload. Infrared sensors and telemetry and communications equipment are known to be aboard, although the Air Force hasn't released details on the payload.

The 3500-lb Midas is in a polar orbit, traveling 1850 miles high in in a near-perfect circle. It is the heaviest U. S. satellite yet to be placed in a high orbit, and the booster, an Atlas D, had to be modified for the job. Heavy stainless steel was added in the upper portion of the missile's lox tank during airframe manufacture.



Fired by an Atlas (A), the Agena-B satellite used as Midas III coasted into a highly elliptical orbit (B). When ignited (C), the Agena came up to circular-orbit speed, changed altitude, and nosed down into a stable position (D). Infrared sensors get a good view of the earth in that position.

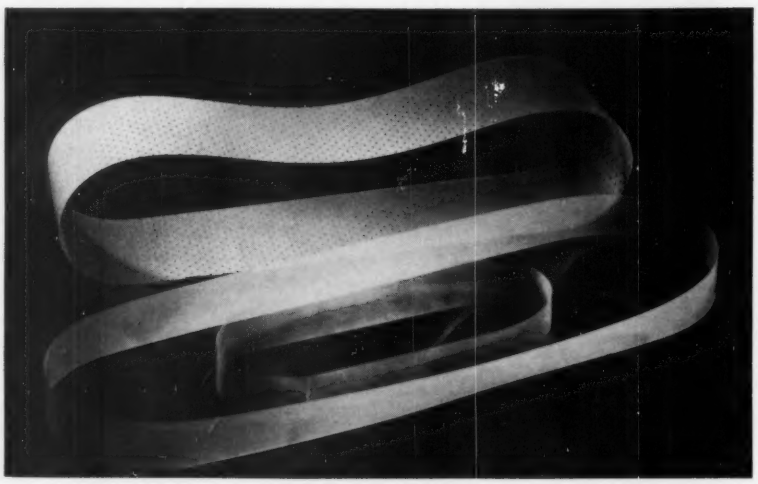


Modified Atlas booster stands approximately 68-ft tall, weighs 260,000 lb when fueled, and develops a thrust of 360,000 lb. The Agena-B is about 30 ft high, 5 ft in diam. It is propelled by a 15,000-lb thrust engine that has restart-in-space capability.

Drive Belts Spliced by Ultrasonics

CRANFORD, N. J.—Thin-film drive belts can now be ultrasonically spliced to more than 90 per cent of the strength of the belt material. Developed for satellite tape recorders (MD, October 27, 1960, pp. 137-143), the belts have found numerous power-transmission, conveying, and instrumentation applications because of their flexibility, tolerance for stress and fatigue, and ability to operate at high speeds.

The new splicing technique, developed by International Ultrasonics Inc., can be used with Mylar belts of any length, widths from 1/4 to 60 in., and thicknesses of more than 10 mils. Overlap is 0.05 in. (within 0.001) and the joint is reported no more than 10 per cent thicker than the mill material.



Ultrasonic splicing of thin-film belts is claimed less complex than other methods. Unlike heat splicing, it dosen't disturb polyester orientation.

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This Self-aligning Ball Bushing is designed for tough work...takes misalignment in its stride while supporting the heaviest radial, thrust or combined loads. Even low frequency oscillating operation can be accommodated.

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Circle 210 on Page 19

New Process Breaks Nylon Part Size Barrier

Largest monomer cast MC nylon parts produced to date have been semi-finished symmetrical shapes in the 500 to 700-lb range. Polymer says that, theoretically, there is no limit to the size part that can be made. MC nylon is now available in stock bars and plates.

READING, PA.—A new nylon casting process for the first time permits low-cost production of large, complex nylon shapes and parts. Announced by Polymer Corp., the development makes available a new material for the design of large bushings, cams, rollers, and contour wear parts such as tooling dies, linears, and guide blocks.

Described as "monomer casting" (direct conversion of nylon from chemical raw materials to finished part), the process is said to be similar in technique and cost to the conventional casting of metals.

The material, designated MC nylon, is a Type 6 formulation. However, according to Polymer, it exhibits physical characteristics which span the range of properties obtainable in nearly all nylons in industrial use today.

"Until now, the inherent advantages of nylon have been unavailable in large parts because of the high tooling costs and processing limitations of conventional molding methods," says Louis L. Stott, Polymer president. "In monomer casting of MC nylon, direct production of finished nylon parts from monomer, rather than from powders of nylon polymer, cuts raw material costs in half. Since monomer casting is performed at atmospheric pressure, expensive molds required in conventional injection or extrusion molding of nylon polymers are eliminated." He emphasized, however, that the new process will not compete with injection molding now widely used for mass production of small parts.

The basic chemistry involved in monomer casting was discovered by Monsanto Chemical Co. Polymer Corp. has acquired the exclusive right to use the process in the field of casting nylon shapes in the U.S. and abroad.

'Revise Retirement Tax Laws,' NSPE Tells Senate

WASHINGTON—Present Federal tax laws inhibit self-employed professionals from establishing their own retirement programs and are a "roadblock" to complete development of self-reliant, individualistic engineers, the National Society of Professional Engineers told the Senate Finance Committee. The Society's views were expressed during Committee hearings on a House-passed bill that would authorize the self-employed to deduct income set aside for retirement purposes.

"By permitting a self-employed engineer an equal chance for retirement benefits, the Keogh-Utt bill will materially assist opportunities for freedom of thought and activity . . . It is vitally important for the Federal Government to do what it reasonably and properly can to place no roadblocks in the paths of those whose specialized knowledge may best be utilized as self-employed consultants."

The pending bill, with its features liberalizing retirement programs, "would be a major contribution toward the enhancement of the professions from an economic standpoint and would assist in establishing a climate favorable to the professions for career development."

Under the Keogh-Utt bill, self-employed persons with less than four regular employees could establish retirement plans and defer up to 10 per cent of their self-employment earnings, or $2500, whichever is less, for amounts set aside to provide for their future retirement. Self-employed individuals with four or more employees, however, would be required to set up a nondiscriminatory retirement program for their employees before they could establish a retirement plan for themselves. Sums set aside would not be taxed until they are received as income after retirement.

More Materials Data Needed Before Man Goes Far in Space

NEWPORT BEACH, CALIF.—The success of programs to develop manned spacecraft depends on development of materials technology that will solve problems introduced by the space environment, according to Dr. George J. Mills, Aeronutronic Div., Ford Motor Co.

"Materials for space application will involve entirely new considerations. We have tables and tables of materials data which at the most can serve only as crude guidelines. We have become so accustomed to accepting engineering data for 'earth-environment' applications that we have lost sight, to a degree, of the critical parameters responsible for materials behavior."

Different Approach Required

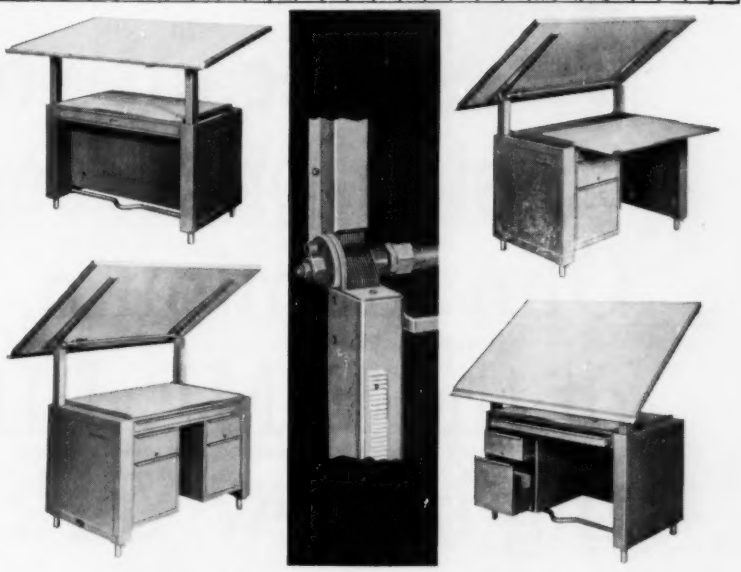
If a spacecraft is designed to survive all possible hazards, Aeronutronic-Div. scientists agree, it would be too heavy to get off the ground. A different approach is needed. Instead of designing to a given factor of safety, probability of occurrence of certain loads will be the criteria. A reasonably lightweight vehicle can be built if its structure need only show a certain realistic probability for survival and protection of the crew.

Theory and data cannot yet be applied to the development of shielding for space. Structure designers, health physicists, and shielding specialists have not determined efficient combinations of materials and wall thicknesses that will protect men and equipment from radiation. Other materials problems must also be solved: Fail-safe structural tests, creep studies of dual-wall pressurized structures, and simulated environmental tests remain to be made.

Vacuum Causes Problems

The effect of high vacuum is particularly important, because current work shows that some mechanical properties change during exposure to high vacuum. Another important area is the outer-shell surface of a space structure: There is a serious lack of chemical-stability data for outer-shell materials that would be exposed to vacuum and radiation for extended periods.

DRAFTING TRENDS



Four views of the versatile new Torsion Auto-Shift Table and the heart of its exclusive new design principle.

Efficient, Convenient, Contemporary . . . New Torsion Auto-Shift Table

Advanced design—A searching look will tell anyone who uses a drafting table that this is the equipment he'd create, given the time.

As any designer knows, simplicity is often difficult to achieve, and the appearance of simplicity even more difficult. Both are found in exclusive features of the new Hamilton Torsion Auto-Shift.

Tailored to the user—Unlike other designs, this is engineered, functional equipment for drafting, not just a drawing board slung on four legs or hung on a modified office desk. *It is designed without compromise to promote greatest efficiency by adapting to the work habits and convenience of the individual using it.* Its special characteristics will speed drafting substantially over conventional equipment in a one-man or one hundred-man department.

Unique features—The Hamilton Torsion Auto-Shift will counter-balance, regardless of table angle or weight of board accessories. It is attached and pivots at only two points—atop twin elevating columns, easily raised or lowered by foot pressure through a 12" vertical range. Operating and adjusting mechanisms are readily accessible—without the need for bulging sheet metal covers or protruding hardware.

Stratacore® board—Further features include the new Stratacore drawing board . . . a light weight, linoleum-surfaced top of remarkable strength and stability. Slide-type reference surface can be used from front or rear. All drawers are reversible for use from one side or the other. Tool and catalog drawers may be installed at left or right, or on both ends.

Clearly, the new Hamilton Torsion Auto-Shift now offers even greater dividends for long-term investment in space economies, increased drafting output and improved user comfort.

Ask your POST dealer for full details, layout aids and planning assistance to put this prestige drafting furniture in your *near* future. Or, write Frederick Post Company, 3652 No. Avondale Ave., Chicago 18, Ill.

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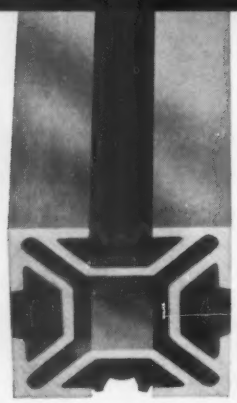
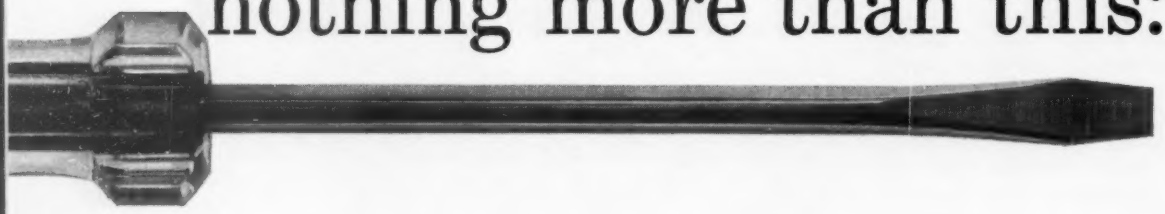
Circle 211 on Page 19



Because of this extrusion, engineered with Olin Aluminum, 15 floors of the TIME-LIFE building in New York City can be quickly re-shaped with nothing more than this:



Olin engineers helped design this unique extrusion to serve as the universal junction of movable wall panels. The genius of this extrusion makes it possible to change office size, shape and color in jig time with nothing more than a screwdriver! So many Olin ideas like this have saved so much time and money for fabricators, designers and architects that modesty forbids telling all. As versatile as aluminum is, it doesn't think, doesn't create designs, or doesn't fabricate itself. That's why Olin Aluminum offers you the services of its marketing and technical staff. They "think aluminum." Don't you think it would be a good idea to call Olin?

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Circle 212 on Page 19

Reader Information Service

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- Free catalogs, bulletins, literature
- Information about new parts, materials
- Design data on advertised products
- Extra copies of editorial articles

HELPFUL LITERATURE

Descriptions of items start on Page 196. Starred items are from August 3 issue.

Electrical, Electronic

502 Variable Transformers. 40 pp. Standard Electrical Products Co.

506 Engine Controls. 12 pp. Synchro-Start Products Co.

513 Printed Circuits. 14 pp. U. S. Engineering Co.

518 Precision Resistors. 6 pp. Ward Leonard Electric Co.

520 Panel Instruments. 6 pp. Weston Instruments Div., Daystrom Inc.

527 Selenium Rectifiers. 4 pp. Semiconductor Div., Syntron Co.

529 Mesa Transistors. 8 pp. Motorola Semiconductor Products Inc.

530 Numerical Control. 32 pp. Friden Inc.

536 Miniature Potentiometers. 4 pp. Trans-Sonics Inc.

538 AC Gearmotors. 2 pp. Ohio Electric Mfg. Co.

539 Control, Torque Synchros. 4 pp. Vernitron Corp.

544 Shell-Type Motors. 4 pp. Louis Allis Co.

546 General-Purpose Relays. 4 pp. Ohmite Mfg. Co.

598 Circuit Breakers, Safety Switches.* Highlights advantages of AB-I circuit breakers. 32 pp. Standard Control Div., Westinghouse Corp.

599 Variable Transformers.* Series 21 Powerstat units have output rating to 3.75 amp. Bulletin P 6121, 8 pp. Dept. 21, Superior Electric Co.

600 Selenium Photovoltaic Cells.* Have high sensitivity at low light levels. Bulletin 03-201-A, 6 pp. Weston Instruments Div., Daystrom Inc.

601 Small Induction Motors.* Fhp motors are rated from 15 mhp to ½ hp. Bulletin GEA-7300, 6 pp. General Electric Co.

602 Pilot Lights.* Covers a wide range of pilot lights and lamps for which they were designed. Form L-161 C, 24 pp. Dialight Corp.

603 Electrical Contacts.* Includes charts, specifications, design factors for various types of contacts. 10 pp. Tricon Mfg. Co.

604 Controlled Speed Systems.* Twelve typical systems are illustrated and described. Form F-1952, 8 pp. U. S. Electrical Motors Inc.

605 Ceramic Capacitors.* Glennite units in six case sizes in each temperature characteristic. Bulletin H-4, 16 pp. Gulton Industries Inc.

Hydraulic, Pneumatic

505 Control Valves. 16 pp. Conoflow Corp.

507 Seals and Fasteners. 16 pp. A.P.M. Corp.

509 Air Valves. 4 pp. Barber-Colman Co.

523 High-Pressure Valves. 8 pp. Watson-Stillman Press Div., Farrel-Birmingham Co. Inc.

525 Gasket Materials. 24 pp. Garlock Inc.

526 Vane-Type Fuel Pumps. 6 pp. Vickers Inc.

528 Vacuum-Pump Selector. Fast Mfg. Corp.

532 Premium Lubricants. 20 pp. Hercules Packing Corp.

534 Molded Packings. 8 pp. Greene, Tweed & Co.

541 Fans, Air Washers. 36 pp. Industrial Plastics Fabricators Inc.

543 Centrifugal Pumps. 6 pp. Aurora Pump Div., New York Air-Brake Co.

545 Pressure Regulator. 4 pp. Lexington Controls Inc.

606 Hydraulic Equipment.* Reservoirs, oil-level sight gages, power-unit accessories. 20 pp. Century Hydraulics Div., Century-Detroit.

607 Butterfly Valves.* For pressures from vacuum to 150 psi. Bulletin 6, 4 pp. Henry Pratt Co.

608 Air-Hydraulic Cylinders.* Complete selection data. Bulletin AJH-1045, 32 pp. Miller Fluid Powder Div., Flick-Reedy Corp.

609 Molded Cups.* Specifications of units for hydraulic and pneumatic service. Folder AD-189, 4 pp. Garlock Inc.

610 Fluid-Flow Regulators.* Lee Jets restrict and regulate fluid flow. Bulletin LJ-1, 4 pp. Lee Co.

611 Ball Valves.* Characteristics and specifications of Flo-Ball valves. 16 pp. Hydromatics Inc.

612 Motor-Pump Units.* Have capacities to 26 gpm and pressures to 350 psig. Bulletin 150.7, 4 pp. Moyno Pump Div., Robbins & Myers Inc.

Mechanical Equipment

516 Ball Bearings. 4 pp. Saginaw Products Corp.

517 Adjustable-Speed Drives. 16 pp. T. B. Wood's Sons Co.

522 Sprockets and Hubs. 4 pp. Browning Mfg. Co.

533 Roller Chain and Sprockets. 106 pp. Acme Chain Corp.

613 Flexible Couplings.* With fixed and plain bores for reboring. Bulletin 10, 4 pp. Acme Chain Corp.

614 Flexible Couplings.* Para-flex units in standard, high-speed, flywheel types. Bulletin 901B, 24 pp. Dodge Mfg. Corp.

615 Self-Sealing Couplings.* Answers questions on the use of these couplings. Bulletin 629, 20 pp. Aeroquip Corp.

Assembly Components

504 Standard Plastic Parts. 12 pp. Harry Davies Molding Co.

510 Casters and Wheels. 48 pp. Hamilton Caster & Mfg. Co.

512 Stainless-Steel Screws. 4 pp. Standard Pressed Steel Co.

616 Spring Pins.* Sixteen applications for Sel-Lok spring pins. Form 2670, 8 pp. Standard Pressed Steel Co.

617 Locking Devices.* Data on pin-tumbler cam locks and accessories. 12 pp. Corbin Cabinet Lock Div., American Hardware Corp.

618 Inserts and Studs.* Keensert one-piece units described. Catalog D, 28 pp. Newton Insert Co.

Materials

501 Silicone-Rubber Products. 12 pp. Dept. SI, Hewitt-Robins.

508 Polycarbonate Films. 14 pp. Chemical Materials Dept., General Electric Co.

514 Rhenium, Rhenium Alloys. 12 pp. Rhenium Div., Chase Brass & Copper Co.

519 Plastic Optical Lenses. 8 pp. Stocker & Yale Inc.

521 Beryllium-Copper Strip. 16 pp. Brush Beryllium Co.

535 Vinyl Resins. 14 pp. Vinyl Products Div., Electrochemicals Dept., E. I. du Pont de Nemours & Co.

537 Aluminum Casting Alloy. 8 pp. William F. Jobbins Inc.

540 Resistance Alloy. 8 pp. Hoskins Mfg. Co.

542 Vinyl-Aluminum Laminate. 20 pp. Aluminum Co. of America.

619 Pressure-Sensitive Tapes.* Reference data on various types of pressure-sensitive tapes. 44 pp. Industrial Div., Mystik Adhesive Products Inc.

620 Tungsten Alloy.* Properties of Kennertium W-10 alloy. Bulletin B-500, 8 pp. Kennametal Inc.

621 Polypropylene Plastic.* Physical properties, characteristics of Tenite. Materials Bulletin 9, 7 pp. Plastics Div., Eastman Chemical Products Inc.

622 Rubber Sheet Packing.* Describes 15 natural and synthetic-rubber sheet packings. Brochure PK-170A, 4 pp. Packing Materials Div., Johns-Manville.

623 Stainless Steels.* Precipitation-hardenable steels have high corrosion resistance. Booklet Adv. 1223, 32 pp. Republic Steel Corp.

624 Plastic Tubings.* Flexite Shrinkdown tubings expand, then shrink to fit snugly. Bulletin 5, 4 pp. C. Frank Merkell & Sons.

625 Polysulfide Liquid Polymers.* Thiokol polymers for use in industry. Booklet IA-200, 8 pp. Thiokol Chemical Corp.

Engineering Dept. Equipment

503 Metal-Sheathed Thermocouples. 4 pp. Harco Laboratories Inc.

511 Strain Gages. 4 pp. Micro Systems Inc.

515 Pressure Transducers. 6 pp. Controls Div., American-Standard.

524 Drafting Furniture. 4 pp. Stacor Equipment Co.

531 Weldable Strain Gage. 2 pp. Microdot Inc.

626 Load-Cell Systems.* Covers 33 capacities in compression, tensile, push-pull models. Bulletin R-2, 12 pp. W. C. Dillon & Co. Inc.

627 Instruments and Controls.* Fluid meters, transmitters, recorders, level transmitters, and temperature instruments. 4 pp. Bailey Meter Co.

628 Formulas Folder.* Pocket guide of data for use in measuring dynamic phenomena. 10 pp. Endevco Corp.

629 Transfer Films.* Diffusion transfer films for engineering and graphic arts. 4 pp. Ampto Inc.

630 Test Instruments.* Optical and physical instruments and apparatus. 28 pp. Gardner Laboratory Inc.

NEW PARTS, MATERIALS, ENGINEERING EQUIPMENT

Descriptions start on Page 210.

Electrical, Electronic

551 Miniature resistors have minimum dissipation of ½ w per wafer. Dale Electronics Inc.

554 Compact heating element produces temperatures over 300 C. Corning Glass Works.

564 Micro-photo-sensor provides sensitive light spot displacement measurements. Micro Systems Inc.

566 Electric motors have load speeds from 2500 to 20,000 rpm. Heinze Electric Co.

567 Selenium rectifiers have cells of 0.010-in. aluminum stock. Rectifier Components Dept., General Electric Co.

571 Resistor networks are made to tolerances of ±1 per cent. Intellux Inc.

574 Terminal blocks incorporate positive quick disconnect. Kulka Electric Corp.

577 DC motors offer full ac-dc interchangeability. Bristol Motors Div., Vocaline Co. of America Inc.

579 Teflon-insulated terminals withstand temperatures from −100 to +250 C. Microdot Inc.

581 Binding posts have plastic molded parts. Superior Electric Co.

584 Pushbutton switch has snap drive for positive operation. Unimax Switch Div., Maxson Electronics Corp.

587 Microminiature capacitor has variation of less than 10 per cent from −55 to +150 C. American Components Corp.

588 Precision resistor is encapsulated in hard glass. Semiconductor Components Div., Texas Instruments Inc.

590 Silicon power transistors operate in temperatures to 200 C. Semiconductor Materials Div., Radio Corp. of America.

592 Silicon rectifiers require no heat sink. Electronic Devices Inc.

Hydraulic, Pneumatic

548 Drain valve drains from within 0.020 in. of tank bottom. Bruning Co.

561 Pulsation dampener for use with pressures to 10,000 psi. Kunkle Valve Co.

565 Spherical plug valve has rapid, quarter-turn opening. Pittsburgh Brass Mfg. Co.

573 In-line removable filter has large filtering area. Nuclear Products Co.

576 Plastic pump has no stuffing boxes or shaft seals. Vanton Pump & Equipment Corp.

580 Check valve of all Pyrex and Teflon construction. Chem Flow Corp.

586 Ball valve for use at temperature to 1000 F. Hills-McCanna Co.

583 Air-line lubricator for service to 150 psi. Hannifin Co.

589 Four-way valve is rated at pressure to 5000 psi. Denison Engineering Div., American Brake Shoe Co.

Mechanical Equipment

549 Gear-drive unit is a compact drive which uses no oil. Machine Control Inc.

550 Self-aligning bearing for mounting in 0.040-in. or heavier sheet metal. Spyraflo Inc.

556 Intermittent-motion drive is available in 40 and 140-deg dwell units. Remmele Engineering Inc.

563 Ball-bearing screw permits freewheeling of the ball nut. Saginaw Steering Gear Div., General Motors Corp.

568 Journal bearings have temperature range from cryogenic to +600 F. Rogers Corp.

570 Sleeve bearings have built-in oil reservoir and bores from ⅛ to 1⅛ in. Carter Mfg. Co.

572 Flat-wire belts of carbon, galvanized, or stainless steel. Cambridge Wire Cloth Co.

Assembly Components

547 Stainless-steel spring wire has tensile strengths exceeding music spring wire. National-Standard Co.

552 Laminated shims of titanium have high tensile strength. Laminated Shim Co. Inc.

553 Subminiature gear clamps in new ⅛-in. bore size. Siamco Div., Tech-Ohm Electronics Inc.

560 Butyrate cable clamps are weather-resistant for outdoor use. Weckesser Co. Inc.

562 Plastic fasteners are available in small sizes. Anti-Corrosive Metal Products Co. Inc.

569 Metal pull handles of high-strength, corrosion-resistant alloys. Industrial Components Div., Raytheon Co.

575 Nylon grommet fits 10 to 24-gage steel or aluminum sheets. Plastiglide Mfg. Co.

578 Self-tapping insert has action which prevents formation of chips. SpeedSerts Inc.

582 Cable clamps are neoprene-coated aluminum. Richco Plastic Co.

585 Concealed latch for use on access panels. Camloc Fastener Corp.

591 Precision dials, verniers have tolerance of 6 min over 360-deg range. Ackerman Engravers Inc.

Materials

555 Two-part epoxy resin for bonding metal to metal has high impact resistance. Miracle Adhesives Corp.

558 Self-adhesive material has service temperature range of −20 to +250 F. Fasson Products.

Engineering Dept. Equipment

593 Drawing-pen set has six interchangeable drawing points. Alvin & Co. Inc.

594 Magnetic-sensing devices for use in temperatures from −40 to +100 C. Semiconductor Div., F. W. Bell Inc.

595 Space electronics template for guidance and control-circuit drawing. Rapidesign Inc.

596 Thermocouple has body of same material as wall of test vehicle. Nanmac Corp.

597 Temperature test chamber has range from −100 to +600 F. Bemco Inc.

Circle the item number for information on products advertised or described, literature offered, and copies of editorial articles.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 267 for other available reprints. Editorial content of MACHINE DESIGN is indexed in the Applied Science Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

17-1 **Engineering and Sales.** Cause of friction between engineering and sales group; what engineers can do to help relations. (3 pp.)

17-2 **The Double-Eccentric Speed Reducer.** Use of standard gear components to achieve extreme speed-reduction ratios at high efficiency. (3 pp.)

17-3 **Hydraulic Pumps and Motors—Part 1.** Using nondimensional performance coefficients for selecting pumps and motors. (5 pp.)

17-4 **Critical Speeds of Coupled Machines.** Method for determining the critical speed, or natural lateral frequency, of an entire system. (7 pp.)

17-5 **DC Motor Control—Part 3.** Physical construction, mechanical operation of basic motor controls. (7 pp.)

17-6 **Mechanical Finishes.** Specifying surface finishes: Types of finishes; finishing methods; factors influencing choice of finish. (9 pp.)

17-7 **Radii of Gyration.** Nomograms for determining k^2 where multiple dimensions occur. (5 pp.)

17-8 **Microsystem Electronics (Abstract).** Catalog of fabrication techniques. (5 pp.)

16-2 **Project Planning.*** Firm foundation for project planning: Using charts and graphs to make accurate predictions. (5 pp.)

16-3 **Wire-Rope Assemblies.*** Selecting wire rope from standard types; designing assemblies. (9 pp.)

16-5 **Impact Loads.*** Predicting effects of suddenly applied loads; designing efficient structural parts. (9 pp.)

16-6 **Petroleum Base Hydraulic Fluids.*** Characteristics of a widely used type of hydraulic fluid. (4 pp.)

16-8 **Planetary Gear-Train Ratios.*** Five key equations which yield train ratios directly; determining whether a train is reversing or nonreversing. (3 pp.)

15-3 **Chemical Cleaning of Metal Parts.*** Selection considerations; descriptions of chemical metal-cleaning processes. (8 pp.)

15-6 **Edge-Lighted Panels.*** Techniques of design and selection of materials for edge-lighted panels and dials. (2 pp.)

15-8 **Gas-Operated Mechanisms.*** Nondimensional graphs simplify calculations of velocity, distance, time. (3 pp.)

14-3 **How Roller-Chain Horsepower Ratings.*** Getting the most out of the new horsepower and speed ratings proposed by chain manufacturers. (4 pp.)

14-8 **Stepped Shafts and Nonuniform Beams.*** Predicting deflections at any point in a stepped shaft or variable-section beam. (6 pp.)

13-2 **How to Sell Ideas.*** Presenting ideas to management; what sales resistance to expect. (5 pp.)

13-4 **Reverted Gear Trains.*** Determining the number of teeth needed to get exact ratios in a reverted gear train. (4 pp.)

12-4 **Clearance in Rolling Bearings.*** Calculation of probable bearing life for any amount of diametral clearance or preload. (5 pp.)

12-9 **Least-Square Lines.*** Techniques for assessing the statistical significance of a line drawn through a series of scattered data points. (8 pp.)

11-2 **Measuring the Engineer.*** Newest methods of aptitude appraisal; procedure for doing the job efficiently. (6 pp.)

11-5 **Seals for Hard Vacuums.*** Design concepts; study results on materials for hard-vacuum, reusable seals. (6 pp.)

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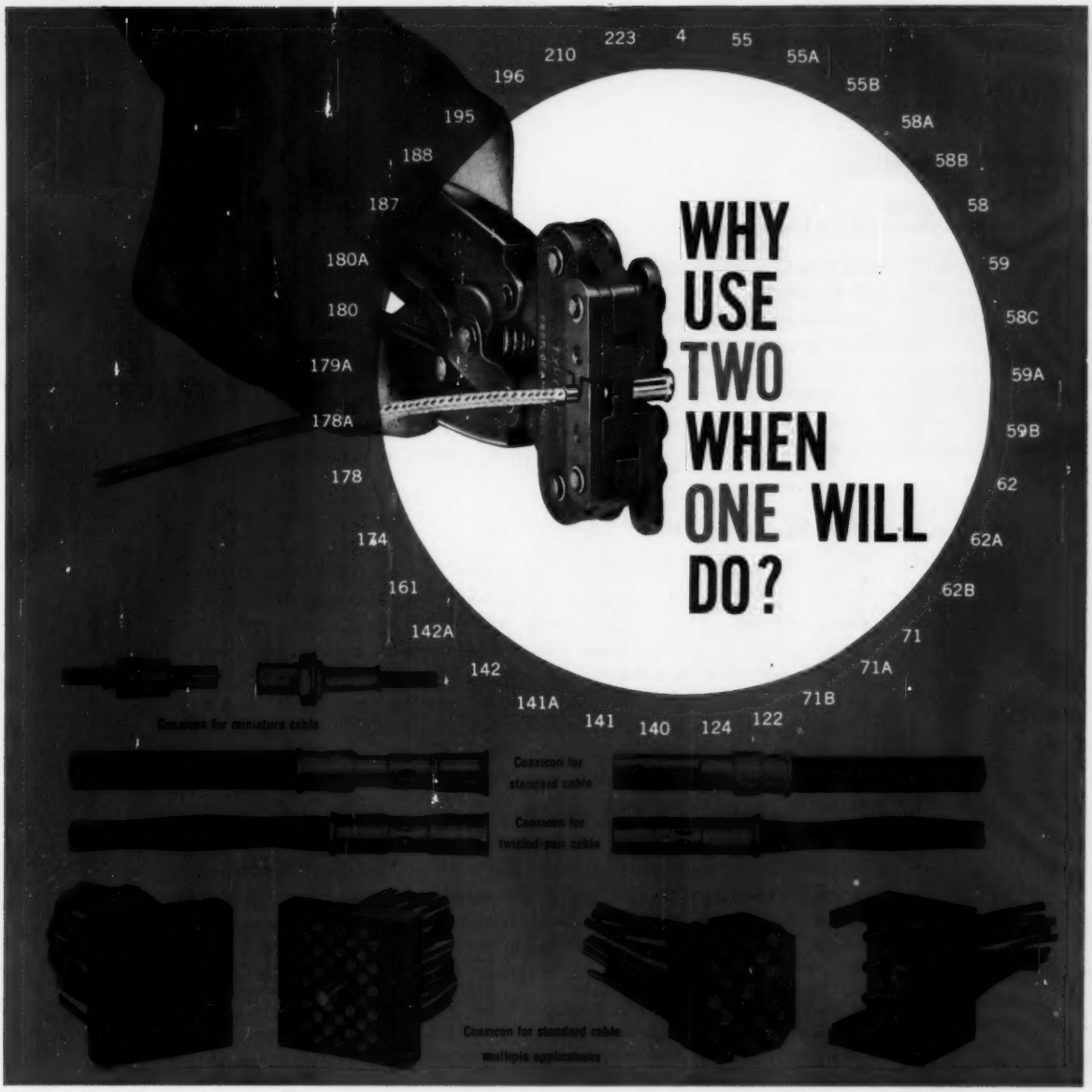

When you've got to attach a connector contact to the end of a coaxial wire, a single precise stroke of a crimping tool (one that crimps braid and inner conductor to the contact simultaneously) is the fastest way, the lowest-installed-cost way, the way that cuts human error in half . . . THE AMP WAY.

Our COAXICON® contact is designed on this principle: two strokes here is one too many!

COAXICON is a one-piece contact. It can be attached, simultaneously, with a single crimping tool stroke, to the braid and inner conductor of 37 sizes of RG/U coaxial cable up to ¼" O.D. (see size numbers above). And AMP makes the tools — hand and automatic — that control the crimp.

COAXICON consists of polarized, concentric male and female shells, made from drawn parts. The inner contacts, assembled in the shells, will attach equally to solid or stranded conductors. Where contact density is important, a miniature COAXICON fulfills the requirement.

COAXICON connectors will match cable impedances in the 50-100 ohm range, at frequencies as high as 150 megacycles. Impedance mis-match, incidentally, is only 1.06 to 1.09, even at 500 megacycles.

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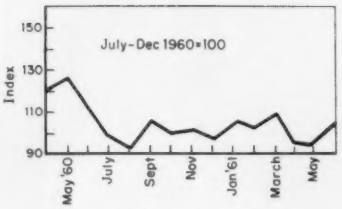
Circle 213 on Page 19

trends

engineering/personal

Welcome Reversal in Employment

Recruiting for engineers and scientists took a sharp upward turn in June, reversing the steady downward trend of previous months. This information comes from Engineer/Scientists Demand Index, compiled by Deutch & Shea Inc., N. Y. Figures are based on newspaper classified and display advertising, and technical-journal advertising. Gain in the June index may mark a turning point in the demand for technical people throughout the country—it occurs at a time when recruiting activities are often at a seasonal low.



More Kudos for VE

Voluntary refund of $1,000,000 was presented to the Army recently by Aerojet General Corp., manufacturer of solid-propellant engines for the Hawk missile. The sizeable check represented savings achieved by Aerojet through a "concerted, corporate-wide value engineering campaign." According to company spokesmen, VE at Aerojet "involves the continual review of designs, products, and processes. We constantly ask ourselves, 'why do we perform specific tasks as we do?' If there is no immediate clearcut answer, we invariably come up with a change that saves money." During the past three years, Aerojet has cut the cost of Hawk motors by 42 per cent.

UNIONS WILL CONSOLIDATE in Calif., if a proposal by president Max Mayfield of the Southern Calif. Professional Engineers Assoc. is accepted. According to Mayfield, his union would join with the Engineers and Scientists Guild and the Engineers and Architects Association to form a statewide confederation of independent engineering unions. Combined membership of the new organization would be about 20,000. It would consist of separate councils for aerospace, governmental, utility, and consulting engineers, with an over-all co-ordinating council. Mayfield has set a two-year timetable to achieve the consolidation.

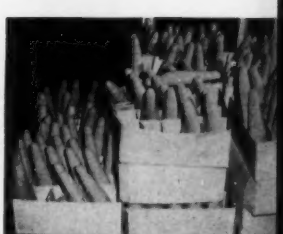
NONPROFESSIONALS MAY JOIN NSPE, according to a proposed amendment to the Society's constitution. The plan, endorsed by NSPE directors, calls for setting up three classes within the Society: Professional-Engineer Member, Member, and Junior Member. A "Member" would be defined as a nonregistered engineer who held membership in an approved national engineering society. In another NSPE move, directors authorized a "Functional Section for Engineers in Industry." The new Section parallels those already in existence within the Society. Its goal: To promote progressive relationships between engineers and management.

Computers

WEEDING OUT accident-prone individuals from applicants for automobile driver's licenses is a reasonable application for computers, according to Dr. D. S. Himmelman, Electronic Data Processing Div., Radio Corp. of America. New bio-medical research shows that computers can be used to excellent advantage for tasks like this. They could also pinpoint critical fatigue levels and check out the alertness of astronauts, commercial airline pilots, and military personnel performing radar watch and other vital duties.

PARADISE STATION, the electric-power installation that is scheduled to be the nation's largest, will have its two turbines automatically controlled by digital computers. And the computers, supplied by TRW Computers Co., division of Thompson Ramo Wooldridge Inc., will also sequence monitor steam generators and sequence cold start, hot restart, and normal and emergency shutdowns. Slated to start operating next year, the TVA facility will produce 1.3-million kw of power.

Malleable Mortar Shells



"A revolution in the casting or artillery and mortar shell" has been announced by Army Ordnance officials. A new process, developed by Albion Malleable Iron Co., Albion, Mich., permits the use of malleable iron instead of forged steel. The end product is praised by the Army as having more effective fragmentation, and has the obvious advantage of containing noncritical material. According to Albion Malleable spokesmen, precisely controlled atmosphere annealing and new ultrasonic inspection equipment makes the new casting process possible.

Air-Cushion Skids

Materials-handling equipment now being designed by Clark Equipment Co. will move loads by floating them on air bearings. Clark has been licensed to use the Glide-Aire ground-effect system developed by Douglas Aircraft Co. While the system was originally intended for handling materials within aircraft, it is equally applicable to railway cars, truck trailers, freight terminals, and warehouses. Experimental units have been tested, and production models next year.

Bones from Castings

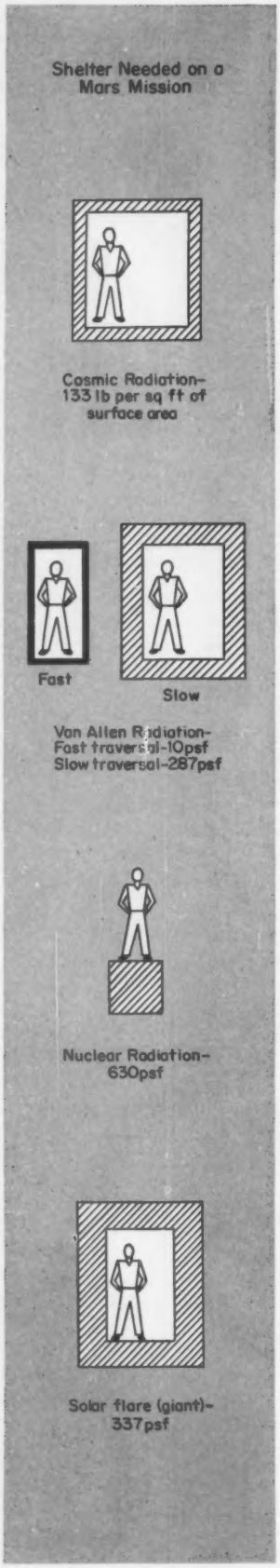
Medical engineering recently received a boost when investment casting proved to be an economical method of fabricating high-strength prosthetic devices. They were previously machined, although the exotic alloys used make machining difficult. Typical is the prosthesis that replaces fractured hip joints. Made from a cobalt alloy, it tapers at one end to insert into the femur, has a bearing at the other to receive the hip socket. The intricate configurations are almost impossible to machine, but investment casting makes fabrication easy.

WORTH 30 TIMES ITS WEIGHT IN GOLD, a little round ball of niobium is being shaped at General Electric Co. as part of a super-accurate inertial-guidance system. Less than 2-in. in diameter, the ball will be freely suspended in a magnetic field, act as a gyro rotor. Once in motion, it may spin for years, say GE engineers.

HYDRIPILLS are a new and convenient source of hydrogen for industrial and laboratory applications. Developed by Metal Hydrides Inc., Beverly, Mass., the pills are a tableted mixture of sodium borohydride and cobalt chloride which react catalytically with water to produce hydrogen. Rates of hydrolysis are rapid.

PINCH-PLASMA ENGINE—one of the most promising battery-powered space drives—will be built by Republic Aviation Corp. Three experimental versions have already proved that the device can combine good efficiency with a broad range of exhaust velocities, stop-start capability, high thrust, simplicity, and reliability. Republic says the new contract takes the plasma-engine principle from the research to possible development status.

GETTING READY to test fire the ion engines, NASA has selected Astro-Electronic Div., Radio Corp. of America, to negotiate a contract for development of payload capsules. Seven will be designed and fabricated, three for ground tests. The first to be launched (late '62) will check out cesium and mercury-fueled ion engines. Flight tests are necessary because the walls of even the largest earth-bound vacuum chambers influence engine exhaust beams.


Shelter Needed on a Mars Mission
Cosmic Radiation–133 lb per sq ft of surface area
Fast
Slow
Van Allen Radiation–Fast traversal–10psf Slow traversal–287psf
Nuclear Radiation–630psf
Solar flare (giant)–337psf

One mission in space means a lifetime radiation dose. Complete protection is out of the question, so designers are considering

Storm Cellars

ONE of the major dangers confronting space crews will be radiation poisoning. To protect against this hazard, designers will have to provide a tremendous amount of shielding. Too little protection would subject astronauts to radiation doses that would take years off their life spans.

Although all the data needed are not yet available, researchers at the National Aeronautics and Space Administration have made rough shield-weight calculations that are the right order of magnitude.* A three-man, three-year mission to Mars, for example, requires biological-shield weights in the 150,000-lb class. This figure is based on present radiation-dosage standards, but even if the acceptable limit is increased threefold, shield weight would be reduced less than 50 per cent. And to get the weight down this low, designers would have to call for movable shields. A liquid that can be pumped into a variety of shelter sizes and types might be the answer.

Four Rays To Duck

Most of the likely candidates for outer-space propulsion systems have one thing in common: They are all nuclear engines. The space men must be shielded from this power plant radiation.

On earth, the atmosphere has a shielding effect comparable to 12 ft of aluminum. Astronauts won't be so well protected from "ambient" space conditions: During one mission they will receive their maximum lifetime cumulative dose.

The first radiation danger encountered will be proton bombardment from the Van-Allen belts. Shielding need not be excessive, provided the craft hurries through.

In deep space cosmic radiation (mostly high-speed hydrogen and helium nuclei) will shower the vehicle continuously. The fastest of these particles are, for practical purposes, impossible to stop; they may require lead shielding 10-ft thick. A small fraction of the slower moving particles are as heavy as iron; if one gets through the shield it could cause a permanent injury.

Protecting against cosmic radiation involves bringing the exposure dose down to a tolerable level. Since the cumulative effect is an important one, designers must know how long the mission will last before they specify shielding.

Another hazard in deep space is the solar flare which shoots out great clouds of particles from the sun's surface. While nearly continuous, most flares are not important. However, a major eruption occurs monthly, and a giant flare happens about once every four years (two were spaced one week apart in 1942). Particles that have extremely high energies are ejected, and the resulting radiation comes in from all directions, not just from the direction of the sun. The space craft about to make a long journey must contain a thick solar-flare shelter that provides protection on all sides; an "umbrella" shield won't work.

Special-Purpose Shelters

On the three-year Mars trip, several types of shelters would be furnished (left). Quarters, measuring a minimum of 1000 cu ft, would be protected by shielding weighing 133 lb per sq ft of surface area.

When within the Van-Allen belts, spacemen will move into smaller shelters in the main quarters. If the passage is to take 12 min, the shelters could be small (100 cu ft) and lightly shielded (10 psf). But if the trip takes two weeks, they must be larger (at least 200 cu ft) and better protected (287 psf).

Nuclear radiation from reactors or ion engines will be easiest to

*Lewis E. Wallner and Harold R. Kaufman —*Radiation Shielding for Manned Space Flight*, NASA TN D-681.

for the Mars Trip

block out because more is known about this type than any other. A 16-sq ft shield that weighs slightly more than 1000 lb should do the job if it is properly located between engines and living compartments.

Solar Flare Rings a Bell

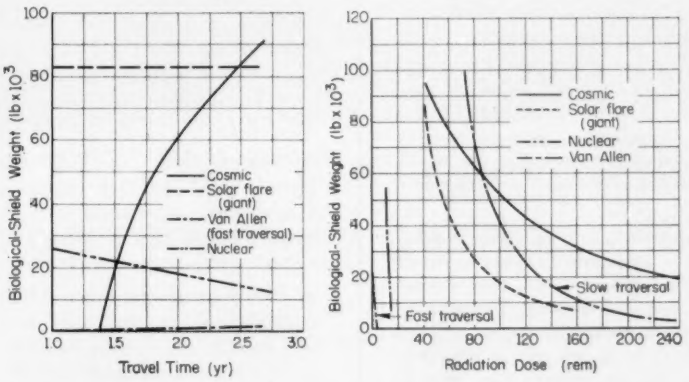
An alarm system will be rigged to warn of a giant solar flare. The entire space craft cannot be shielded against this hazard because the weight of shielding, 337 psf, would be excessive. Even a vehicle designed to pass slowly through the Van-Allen belts (or to orbit within them) would not be burdened with such shielding requirements.

The astronauts will have to climb into solar "storm cellars" and weather out the particle deluge. They will have to stay there one full day, so a minimum volume of 100 cu ft is in order. Radiation getting through the shield, together with cosmic, nuclear, and Van-Allen radiations, will give them a lifetime dose. If two giant flares occur during one mission, the crew could be permanently injured.

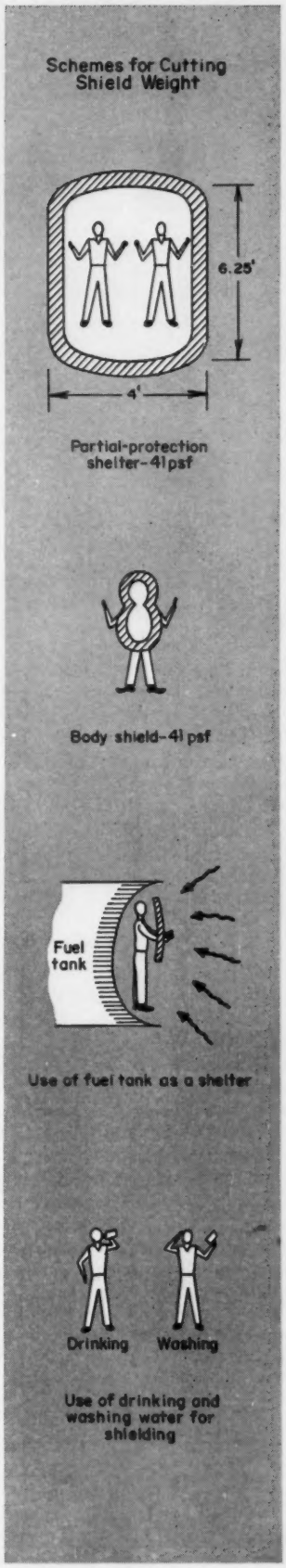
Compromises Planned

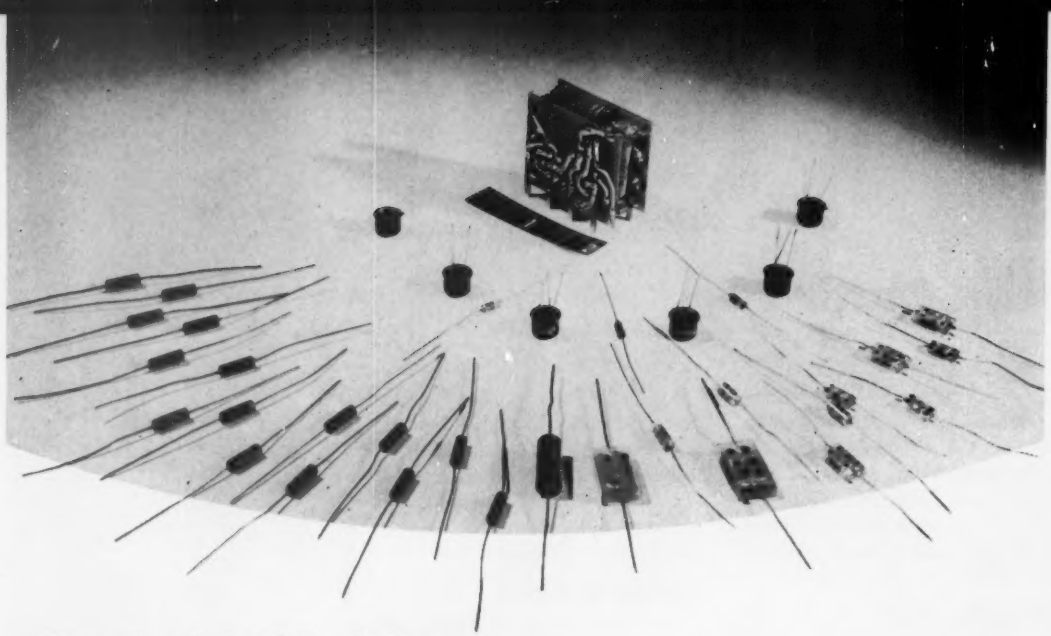
On the first space flights, shield weights will probably not be high enough to protect the crew from giant solar flares. Designers will give them a partial-protection shelter (right) and personal armor to protect head and body trunk. The armor could weigh up to 400 lb.

Added to this protection, the crewman could climb into a cavity in the side wall of the fuel tank, screening out radiation coming in from one or more directions. A third help would be water shielding. Storage tanks in the walls of the vehicle, like the fuel tank, would screen radiation.



Weight of shielding that must be furnished for a Mars trip depends greatly on travel time (left). Cosmic radiation is always present; keeping cumulative dosages below the lifetime limit requires more shielding on slower trips. Giant solar flares occur about once every four years, and flare-shielding requirements won't change on trips that are appreciably shorter than four years. Van-Allen shielding varies with speed through the belts, more shielding being needed on slower trips. Nuclear shielding also drops off with longer travel time; but this is because slower trips permit smaller reactors. Radiation coming through the shields picks up rapidly as shield weight is decreased (3-year trip, right).





Sandwich Modules:

High-Density Packaging Goes Straight

MANY radical approaches to electronic packaging have been developed for aerospace applications. And most of them push the state of the art too far to be commercially feasible.

One of the latest techniques, however, bucks this trend. Developed by Sanders Associates, Nashua, N. H., it packages conventional transistorized circuits into high-density sandwich-type modules. Packaging density has reached 50,000 standard-size MIL components per cubic foot; packaging efficiency approaches 40 per cent. Called "Reliapak" by Sanders, the new technique involves no white-room manufacturing facilities and no oddball components.

How Dense Is Dense?

Claims concerning electronic miniaturization are frequently misleading. In practice, two terms are used to describe space/component relationships:

Packaging Density—an indication of the number of components per cubic foot mounted in a module or subassembly—it may be only a relative yardstick. A packaging density of 40,000 components per cu ft indicates, to one unfamiliar with the terminology, that 40,000 components could be mounted in a volume of 1 cu ft in a functional manner. Realistically, this would be difficult to accomplish because of the necessary bracketry for component mounting and interconnection.

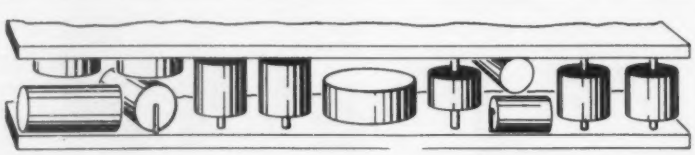
Packaging Efficiency—probably a more accurate description than density—it indicates how well space has been utilized. Packaging efficiency expresses the ratio of the volume of components to be packaged to the total volume allocated to the circuit in the system. A review of literature, however, reveals some disagreement on what is implied in component volume. Many include bracketry and subchassis, which adds 10 to 25 per cent to efficiency. Others consider only the actual volume in the components. The latter is considered in Reliapak construction.

Packaging efficiency usually is no greater than 20 per cent for conventional transistorized circuits; 10 per cent for a good computer-circuit board.

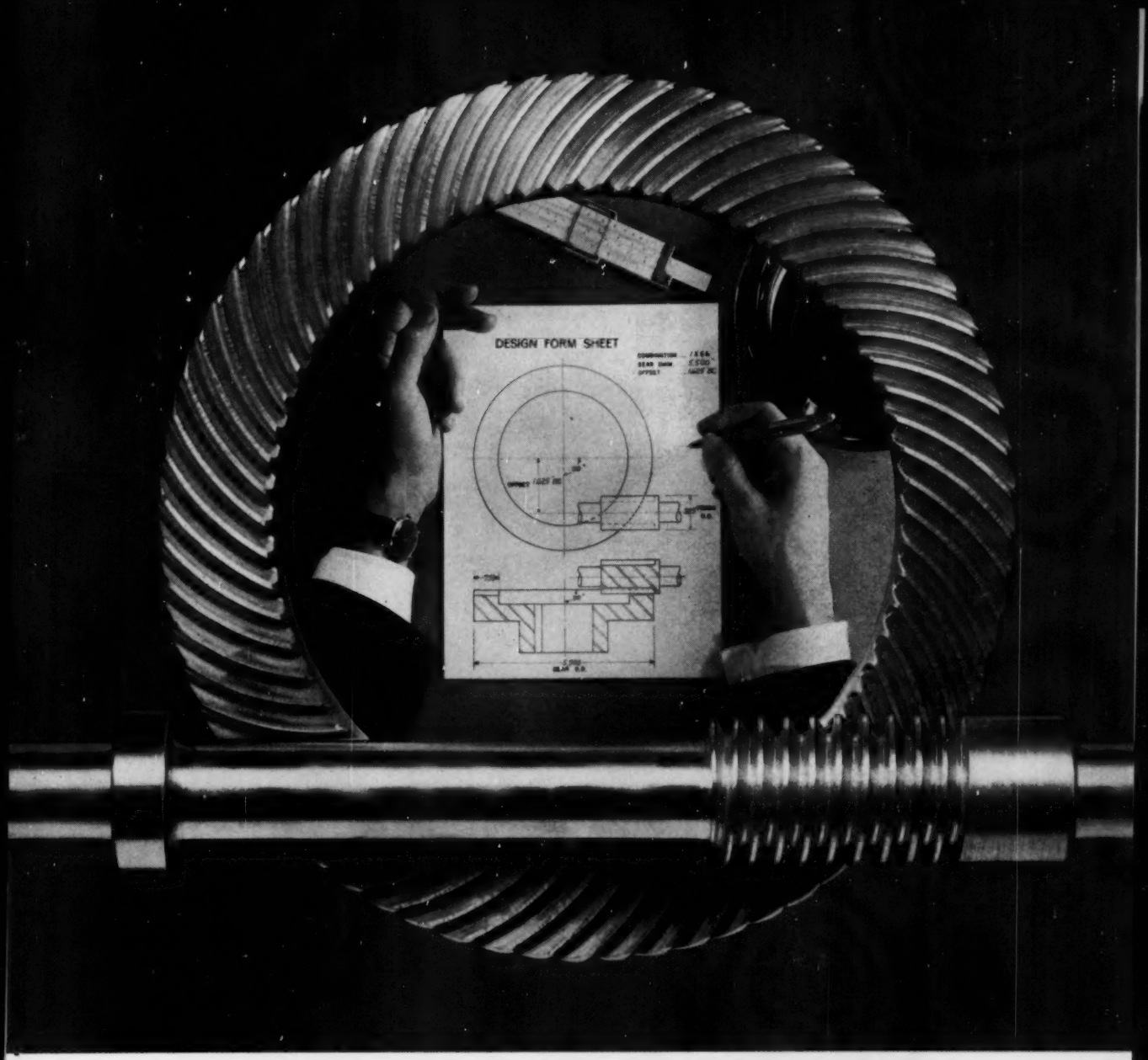
Typical Reliapak modules consist of two ordinary copper-clad printed-circuit boards with electrical conductors etched on both sides. Components are mounted on the boards and as connecting (structural) members between them. Relatively straightforward, the process incorporates several significant advantages:

- Manufacturing ease — Printed-circuit layout and etching techniques are an already familiar and accepted means of mass producing electronic circuitry. Once components are mounted to boards they can be soldered by conventional dip, fountain, or wave-soldering.
- Maintainability — With careful layout, all sensitive components (transistors, capacitors) can be located at the edge of boards to facilitate quick replacement.
- Throw-away concept — Modules, encapsulated or not, can be laid out so that each contains only one or two critical components. If failure occurs, the module can be discarded and replaced by a live unit.

Ordinary plug-in or tab-type connectors are used with the modules.



Typical sandwich module (top of page) contains surprising number of components, several transistorized circuits. Vertical and horizontal mounting of components (left) permits dense packaging without usual connector problems.



Why it will pay to design your high reduction gearing with Gleason HRH*

If you want to make your transmission more quiet or more compact or more flexible, take a good long look at the HRH set shown above.

This single set of gears gives a reduction of 66 to 1.

The action is quiet and smooth and continuous because the pinion teeth *wrap around* the gear teeth. With this design you can work such quiet operation into your designs even with a one- or two-tooth pinion member.

You can add the rigid support of a straddle mounting, since bearings can be put on both ends of the pinion.

HRH gear ratios are made with proven face mill cutting techniques, assuring complete control of tooth contact pattern to compensate for any assembly or operating condition.

HRH gear ratios are designed with the *full* assistance of all Gleason engineering services. We work with you on the practical design aspects and carry through to the development of prototypes. Then we furnish both machines and tooling for full production—*without royalties.*

Find out what HRH gearing can do for your transmissions. Send for our design form sheet and then send us the gear ratios and sizes you want. We'll send back detailed recommendations promptly.

*Trademark for Gleason High Reduction Hypoids

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91

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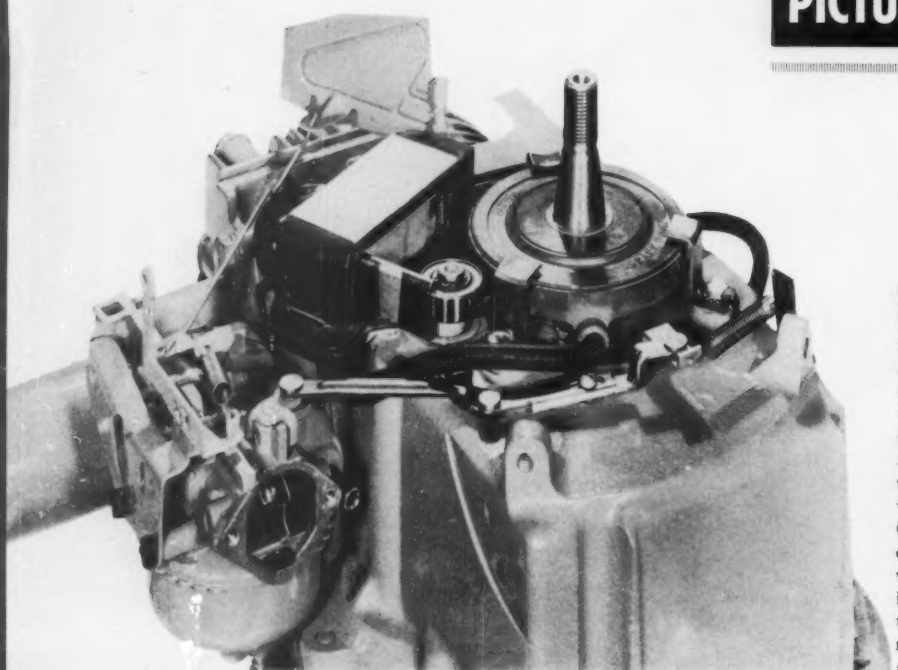
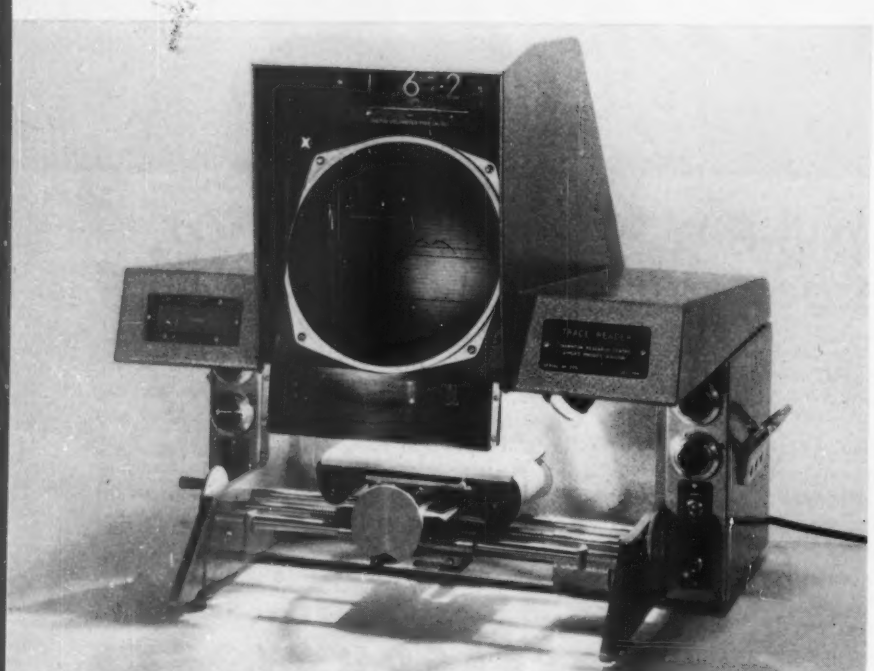
ENGINEERING NEWS

PICTURE REPORT



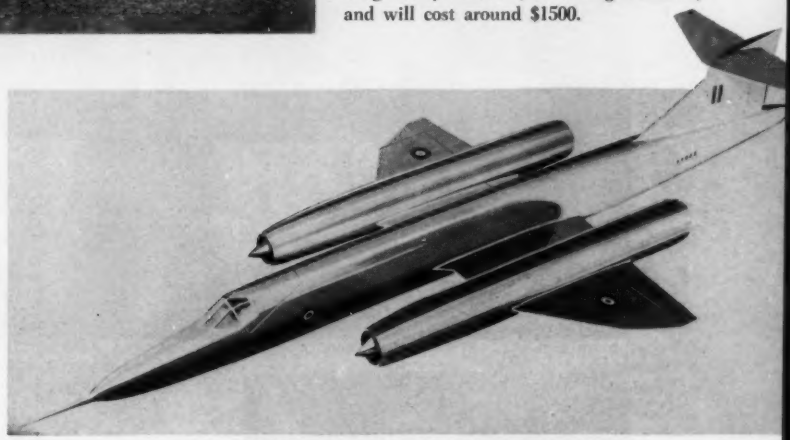
Piezoelectric ignition system on Clinton's new 3.5-hp Dynaspark engine eliminates breaker points, coil, condenser, and magneto. Heart of the system is a Spark Pump developed by Cleveland Graphite Bronze Div., Clevite Corp. The engine is smaller and weighs less than one with a conventional ignition system. Other advantages claimed by the manufacturer, Clinton Engines Corp., are operating economy and low maintenance—as well as freedom from failure due to ignition trouble. First applications of the new engine will be on riding lawnmowers, farm equipment, generators and pumps, and auxiliary drives.



Opaque records up to 120 mm wide can be examined on a trace reader developed at the Thornton, Cheshire research center of Shell Research Ltd., England. The record trace rests on a table which is moved by means of two lead screws along x and y axes in the horizontal object plane of a projection lens. The section of the chart being examined is strongly illuminated and is back-projected at a magnification of 4x. The viewing screen is ruled with two fixed intersecting diameters parallel to the table motions.

Mach 2 missile training target, launched recently at the Naval Missile Center, Point Mugu, Calif., will be operational by October, 1962. The XKD2B-1 will be capable of level flight at any predetermined altitude from 5000 to 70,000 ft. Beech Aircraft Corp. is producing the targets, which are powered by liquid propellant engines built by Rocketdyne Div., North American Aviation Inc. Only 20 in. long and weighing 17 lb, the engine produces 600 lb of thrust.

Electric car called the Voltaram is an experimental model built by Stuart Motors Inc., Kalamazoo, Mich., to prove out design concepts. The company plans to introduce a four-passenger car this fall. It will have a lightweight charger which will operate from any 110-v ac line and, drawing less than 15 amp, will charge the batteries overnight. The Stuart Electric is to cruise at 35 to 40 mph and travel 35 to 50 miles per charge. It will weigh only 1200 lb, including batteries, and will cost around $1500.



Stainless steels in the "largest quantity and variety ever used in a single aircraft design" are incorporated in the British-built Bristol T-188, reports the Committee of Stainless Steel Producers of AISI. The plane, designed to travel at 1500 mph or faster, uses sheet, bar, forgings, piping, and fasteners of stainless. Its 27-ft keel boom and engine nacelle structurals are stainless type 403 forgings.

A single roll of paper collects data on a variety of railroad track conditions in the NCG-Amsler track inspection car. This mobile laboratory simultaneously measures gage (distance between rails); cross level (height of one rail in relation to the other); gradient (rate of ascent and descent); curvature, twist (height of a car wheel in relation to a plane formed by three other wheels); and distance the car travels. Alfred J. Amsler & Co., Switzerland, builds the cars; National Cylinder Gas Div. of Chemtron Corp., Chicago, sells them in the U. S.

Industrial Design

comments and configurations

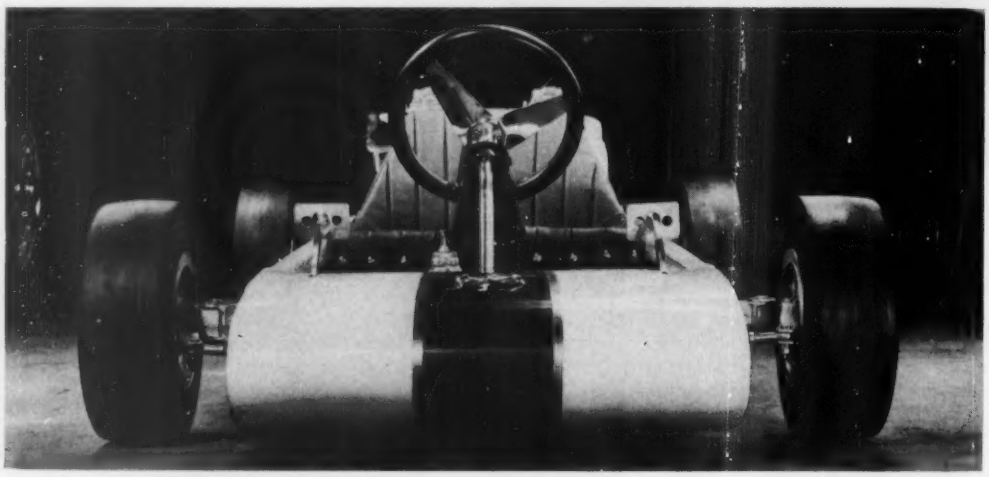
Portable or permanent dishwasher (1) made by Ling-Temco Electronics Inc. offers a choice of seven finishes, three sizes. It can be installed on or under the counter, recessed in or hung on the wall, or as a room divider. It washes with a continuous cascade of water, rather than a spray, then steams the dishes. Components are mounted on a chassis which slides out for service.

Kart (2) designed by Brooks Stevens has exceeded 100 mph in speed trials. Two McCulloch Mac-10 engines power the Excalibur Jr. (named after Stevens' Excalibur sports car); weight distribution is 40-60. Construction is riveted sheet aluminum instead of the tubing usually used in go-karts. It will be built by Gilson Brothers Co., Plymouth, Wis.

Standard bench-type hardness tester can be removed from its stand or frame and equipped with hand grips to check large objects (3). Readings are given in both Vickers (40-1000) and C scales (20-70), and the instrument can be used to test soft metals over 0.6 mm thick. It was designed by Industrial & Automation Div., RCA.

1.

2.



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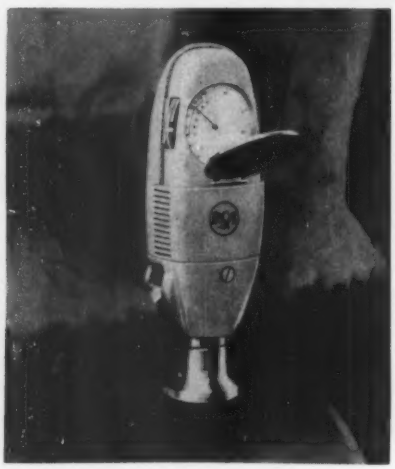
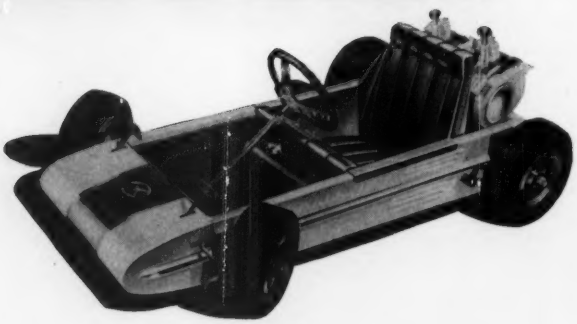
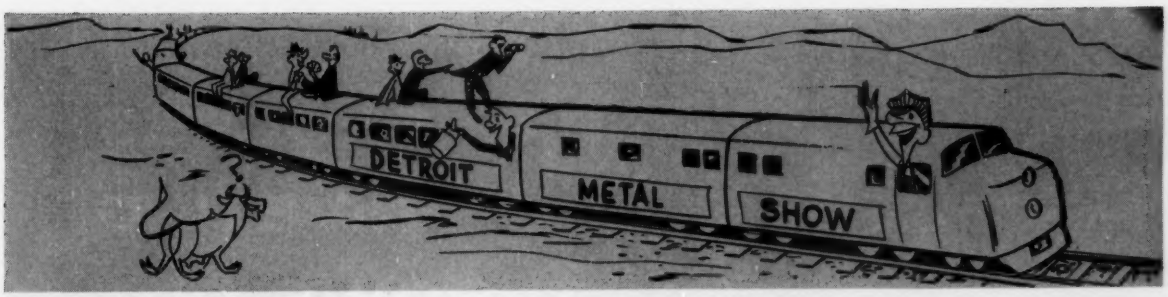
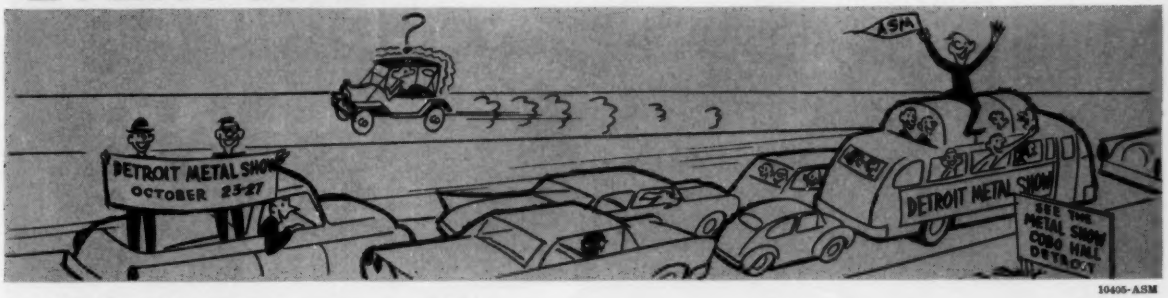






EVERYONE...



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(Well, almost everyone)...

is headed for the 1961 DETROIT METAL SHOW

THE WORLD'S MOST COMPREHENSIVE METALS AND PROCESSING EVENT

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Ideas . . . Ideas . . . Ideas . . . stimulating, thought-provoking ideas. How to improve production . . . how to cut costs . . . how to stay ahead of competition. SEE – hundreds of educational exhibits. HEAR – presentation of over 200 technical papers. EXAMINE – processing, inspection and control equipment. VISIT – the spectacular Materials Comparison Center. Yes, *everyone* . . . especially the IDEA man for his company . . . is headed for the 1961 Detroit Metal Show. He wants to *KNOW* more . . . DO YOU?

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Advance Registration Manager, ASM Headquarters, Metals Park, Ohio
Gentlemen: Please register myself (and the names of my associates listed below) for the forthcoming METAL SHOW at Cobo Hall in Detroit.

Name	Title	Indicate Affiliated Organization*	Registration Fee for ASM Sessions and Exposition: $2.00. (Except as noted below)

(Enclose check or money order) TOTAL

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☐ ASM Members: NO REGISTRATION FEE for ASM Sessions and Exposition.
☐ AIME Members: $5.00 Registration fee includes AIME sessions, ASM sessions and Exposition;
☐ non-members: $10.00 AIME sessions, ASM sessions and Exposition.
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☐ non-members $7.00 SNT sessions, ASM sessions and Exposition.

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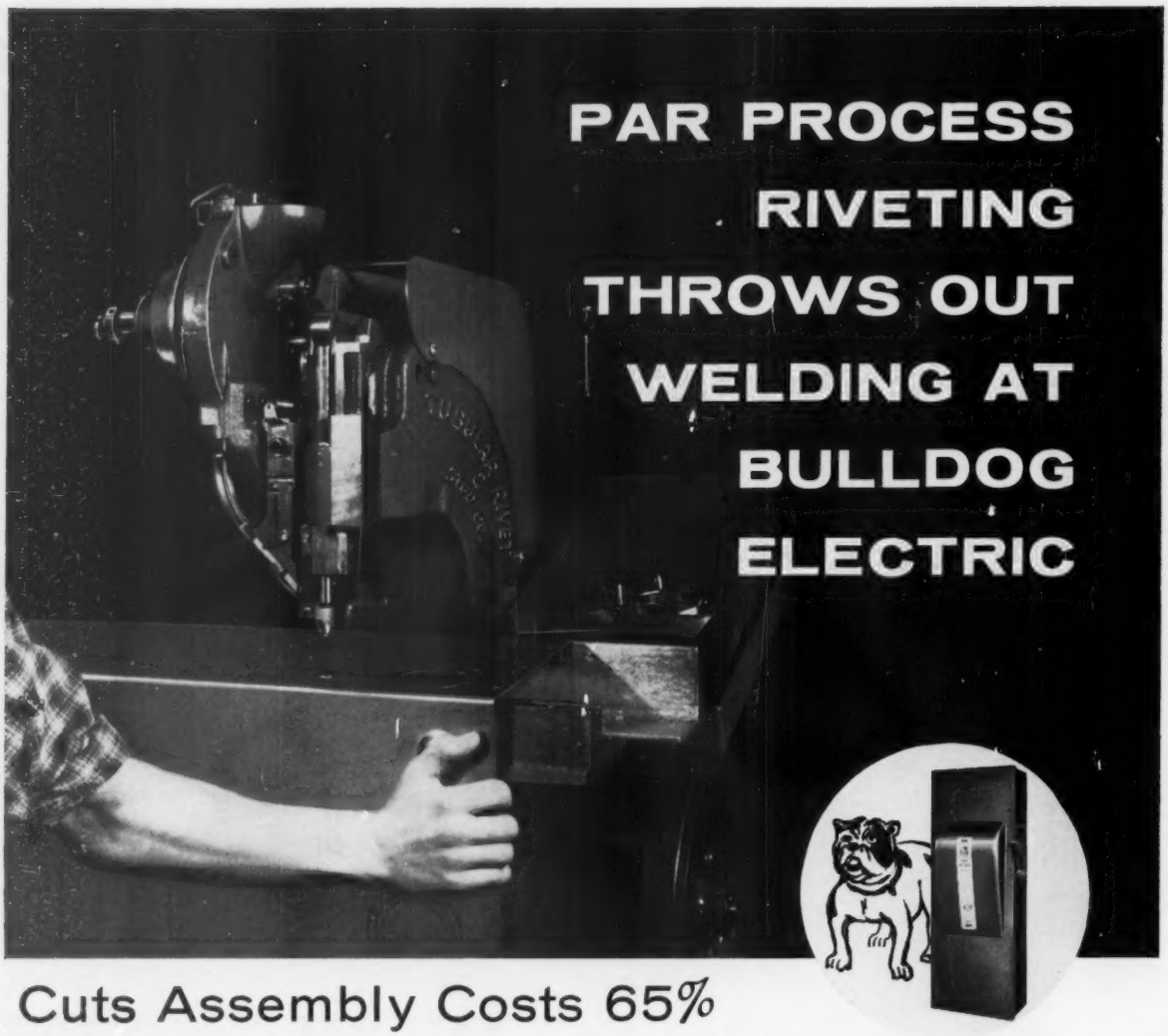

Cuts Assembly Costs 65%

At BullDog, TRS riveting replaced arc welding in assembling components of Vacu-Break® safety switch boxes . . . with an overall saving of 65% in assembly costs. Previously, twelve arc welds were used to secure the two spring stops and mounting rails of each switch box. Special fixtures were required to support parts in the box during welding, and after welding was completed the fixtures had to be dismantled. The entire operation was costly and time consuming.

Trained in the PAR Process approach to cost reduction, the TRS man saw that an automatic riveting set-up could be devised to simplify and speed the work. A roller support was designed to carry the weight of the box, and position the parts for twelve fast operations of a standard TRS automatic riveter. Other details of rivet design, tooling, and setting sequence were quickly solved with the aid of PAR Process know-how. Riveting produced an equally strong assembly and permitted visual inspection of fastenings to assure security.

FIND OUT what the PAR Process can save you
The PAR Process aims at lower costs and higher production rates. It starts with a sharp-eyed, production line search by your TRS man, for ways to eliminate or simplify and speed up steps in assembly. It is made effective by specially organized TRS procedures, backed by unique TRS developments in rivets and riveting machines.
The PAR Process may bring you better integration and fuller automation of assembly operations, or even a cost-cutting change in basic assembly method as with BullDog. Ask for a check of your operations. Whether your assembly jobs are simple or complex, it can be worth dollars to you.

Don't Buy Riveting Machines until you learn how the TRS **PAR** *process revolutionizes riveting*

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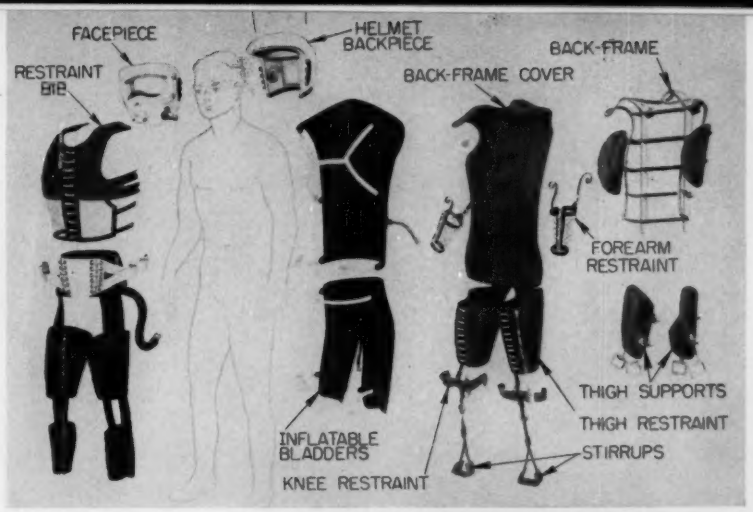
QUINCY 70, MASSACHUSETTS • TRS SALES OFFICES: Atlanta • Buffalo • Charlotte • Chicago • Cleveland Dallas • Detroit • Hartford • Indianapolis • Los Angeles • New York • Philadelphia • Pittsfield • Quincy St. Louis • Seattle. MIDWEST FACILITIES AND STOCK IN CHICAGO. See "Yellow Pages" for phone numbers.

If it's a Tubular Rivet TRS makes it . . . and Better



Mobilizing Man In Space:

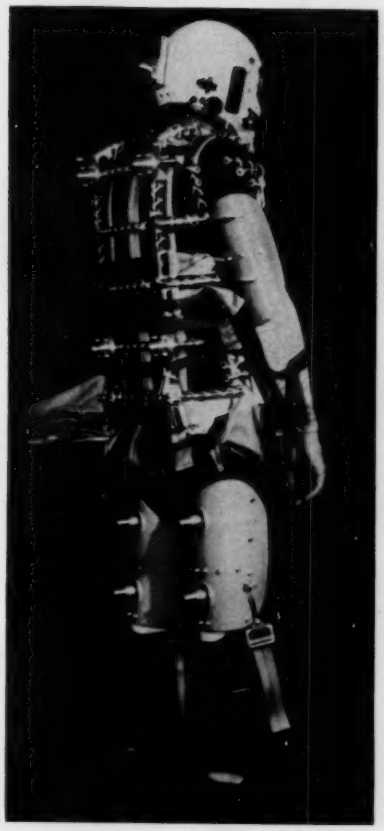
Portable Couch For Astronauts

FUTURE astronauts may fly in a shirtsleeve environment as the result of an NASA research project. A light, mobile support and restraint suit that can be worn as personal equipment was described at the recent Aerospace Medical Assn. meeting by Ames Research Center engineers H. C. Vykukal, R. P. Gallant, and G. W. Stinnett.

Universal in size, the Ames suit weighs only 36 lb. Unlike the costly, individually molded couches used by Mercury astonauts, it would give pilots adequate support against high-g forces applied posteriorly (back toward chest), anteriorly (chest to back), or vertically along the spinal axis. In test-pilot jargon, these forces are respectively termed eyeballs-in (EBI), eyeballs-out (EBO), and eyeballs-down (EBD).

Mercury pilots normally experience only EBI forces during launch and re-entry. A Dyna-Soar or Apollo crew member, however, will be exposed to both EBO and EBD loads as his craft re-enters the atmosphere at high velocity and executes a number of aircraft-like maneuvers in preparation for landing. And where the Mercury pilot "backs" into g forces, the Dyna-Soar man will get full g loading in a face-forward position.

Ames engineers have tested their suit with human subjects under 14-g EBI, 10-g EBO, and 7-g EBD. At the end of centrifuge testing, experienced test-pilot subjects have reported comfort level of the suit to be comparable or better than that of any restraint system they have used.



Quick disconnect of suit and seat is achieved by use of shear pins—one on helmet, four on aluminum backframe, and two on each thigh shell. Release is activated manually by lever-and-wheel arrangement on seat back.

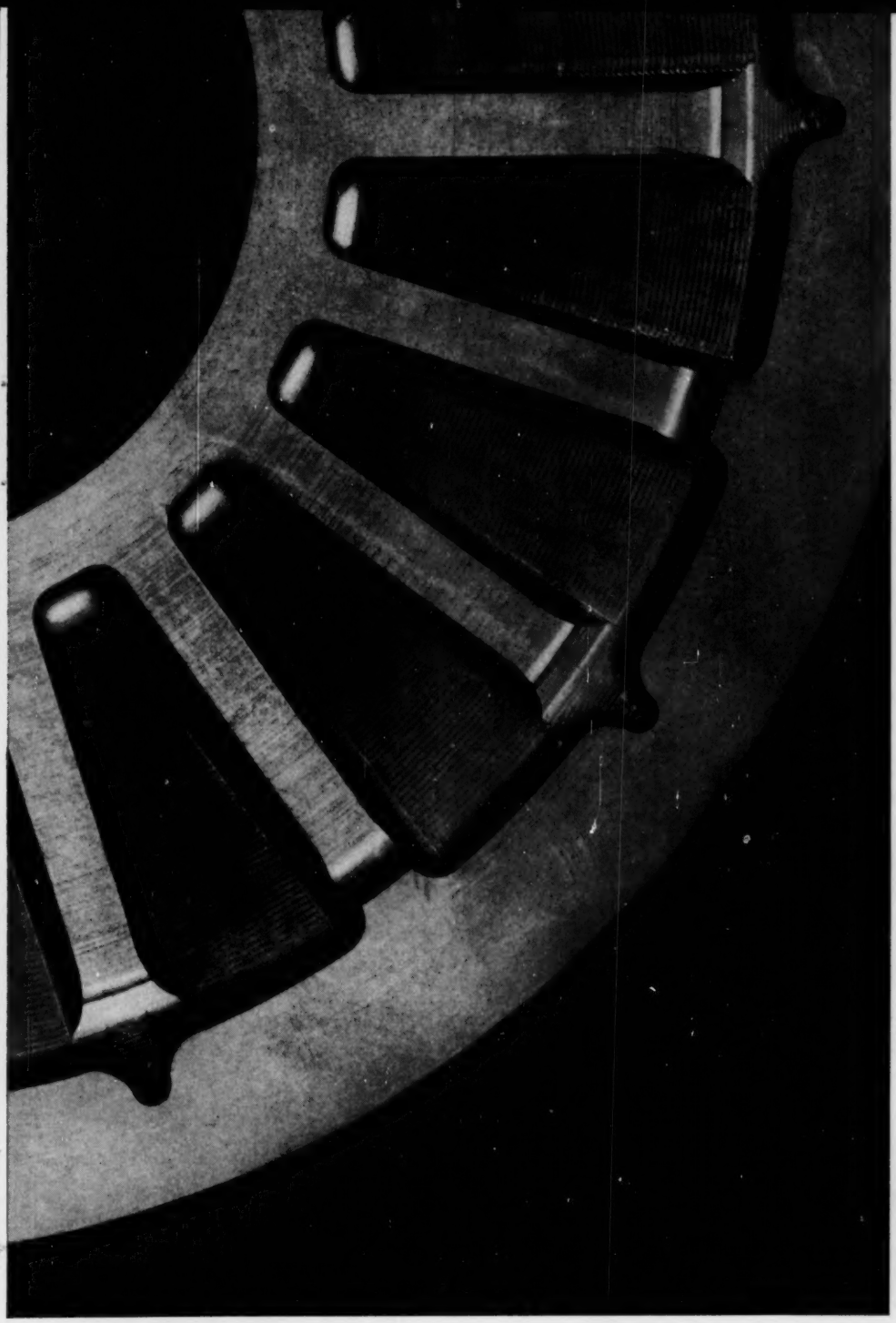
Restraint suit and basic seat comprise the Ames "portable space couch" (pictures). Inflatable bladders are secret of the system: Covering back, buttocks, and thighs, they conform to pilot's seated shape. Merely inflated to a pressure deemed comfortable, they provide same type of support as individually molded Mercury couches.

New IBM computer language...AUTOPROMT cuts milling time for this helicopter gearbox cover by 75%

AUTOPROMT (AUTOmatic PROgramming for Machine Tools) is a powerful new computer language designed to broaden the use of numerically-controlled machine tools.

AUTOPROMT, for the first time, lets an engineer *describe the surfaces* of the three-dimensional shape he wants milled, *rather than calculating every path* the tool must follow in order to machine the part.

AUTOPROMT leaves to the computer the task of automatically generating these tool paths. You describe the part to be milled and the tool to be used in simple, *English-like*



Here's the way AUTOPROMT works at United Aircraft Corporation

The Parts Programmer, using a conventional blueprint, prepares 180 one-line statements in AUTOPROMT language.

The statements are punched into standard IBM cards and entered into the IBM 7090 Data Processing System. (AUTOPROMT also works with the 704 and 709 Systems).

The 7090, programmed with AUTOPROMT, produces 8000 tool path instructions needed to direct the Pratt and Whitney Co. Inc. Numeric-Keller Continuous Path Milling Machine.

Punched tapes direct the Numeric-Keller Milling Machine.

The Numeric-Keller mills the helicopter gearbox cover.

terms. The computer does the laborious calculating work.

AUTOPROMT produces results like these: the time to mill the gearbox shown in the photographs cut to *one-fourth* the machine time required by conventional methods. AUTOPROMT reduced the lead time from blueprint to production *from three months to two weeks.*

AUTOPROMT is available to IBM customers. Call your local IBM Representative for complete details on this latest advance in Numerical Control of machine tools.

IBM®
DATA PROCESSING

Circle 217 on Page 19

Nested in the hull of new nuclear submarines, an emergency propulsion system can be extended when needed Electric drive motor, contained in a massive casing, can operate on standby batteries.

Odds Too Heavy Against One Prop

Nuclear Subs Get Outboard Motors

MILWAUKEE—Secondary propulsion systems, in the form of outboard motors, are being added to all the Navy's nuclear-powered submarines. Louis Allis Co., Milwaukee, is building 29 of the auxiliary units, at least one of which has successfully passed sea trials on the submarine *George Washington.*

The undersea outboard consists of a powerful electric motor mounted on a retractable shaft, the entire assembly fitting between the submarine's pressure and sea hulls. With the shaft extended beyond the sea hull, the unit can be rotated 360 deg for steering. Speed and performance details are classified.

Need for the back-up power source resulted from a basic design change in submarines made several years ago. Most World War II subs, and the early nuclear-powered models, were built with twin-screw propulsion. With one screw out of action, the sub could operate effectively on the other.

All of the new atomic submarines get a boost in speed by relying on a single screw. The reduced margin of safety, however, was considered too much of a gamble shortly after the new subs began phasing into operation. A crash program was initiated among electric-motor builders for the development of auxiliary equipment.

The Louis Allis system, designed and at sea within nine months, is capable of withstanding tremendous pressures and high shock, e.g., hostile depth bombs at a distance of 100 ft. The unit is powered by the submarine's main reactor-turbine-generator plant. In the event of powerplant malfunction or damage, which is extremely remote, the system is backed up with batteries.

Key Agencies Agree on Supersonic Transport

Mach-3 Craft Will Be Built Time Is Still the Question

WASHINGTON—Development of a commercial transport airplane to fly at Mach 3 is feasible, and the craft can be airborne by 1970-1971. Consensus of industry experts is that a world market for upwards of 200 such planes will exist in the next decade.

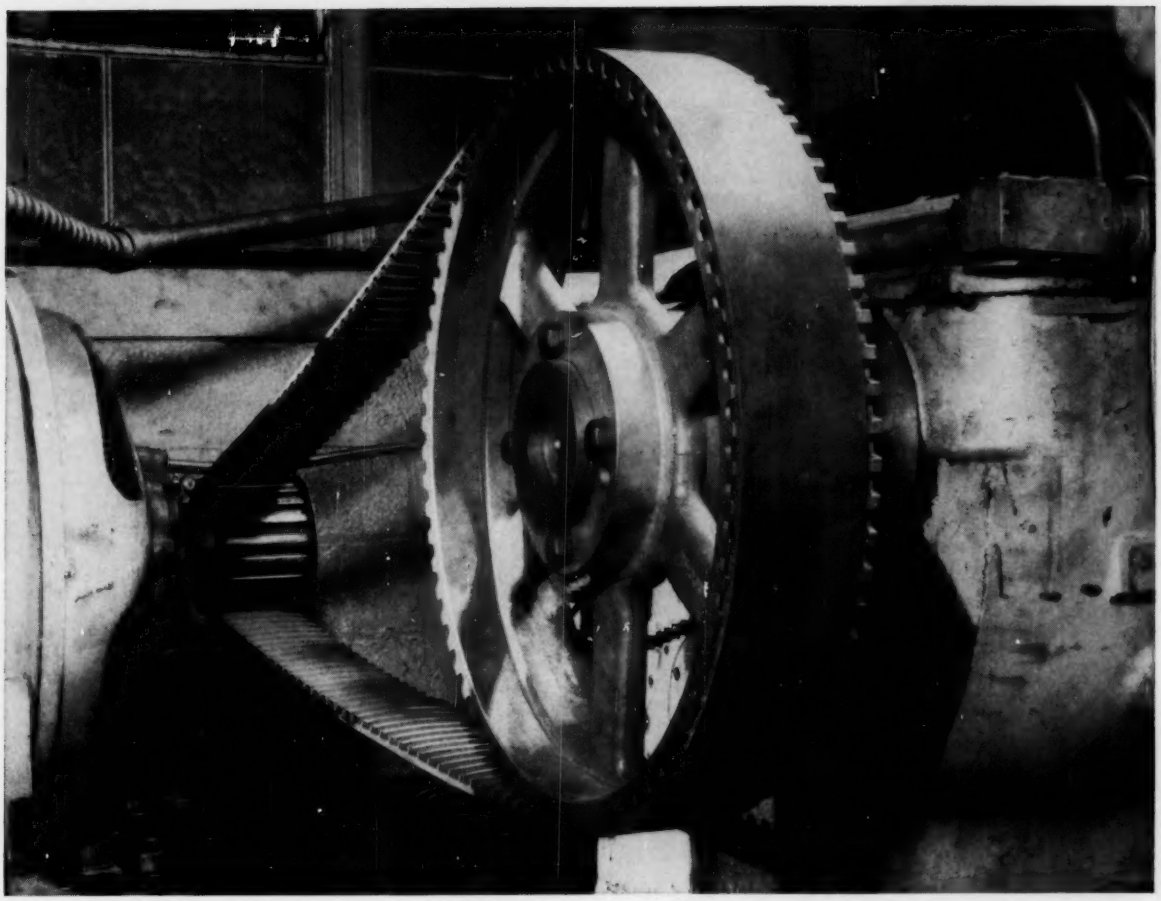
This is the joint conclusion issued by the Federal Aviation Agency, Department of Defense and NASA. A 50-page report, complied by the three groups, notes that the B-58 and B-70 bomber programs provide the U. S. with an ideal jumping-off point for supersonic-transport development. It also notes that industry cannot finance the entire program. The report suggests that:

- Competition should be used to maximum advantage.
- Direct government financial assistance should be provided only to the point where industry can carry on alone.
- Civil air carriers should participate actively.
- Maximum feasible recovery of direct government expenditures should be sought.

Manufacturers have estimated that their planes would have a range of about 3500 nautical miles; they would weigh approximately 400,000 lb, have a 100-ft wing span, fuselage length of 200 ft, and carry from 100 to 150 passengers. Cruising speed would be about 2,000 mph at 70,000 ft.

Aviation industry representatives are agreed that a new engine for the plane must be developed. The greatest power need will be at altitudes over 40,000 ft, where the plane accelerates from subsonic to supersonic speeds. There is virtually unanimous preference for some form of turbofan engine.

Wing design will require considerable research to be efficient at both



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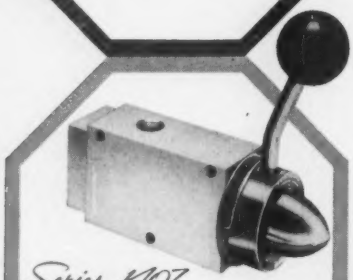
Circle 218 on Page 19

WATERMAN



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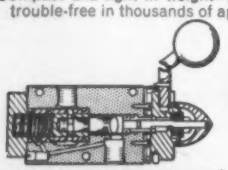

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WATERMAN HYDRAULICS CORPORATION

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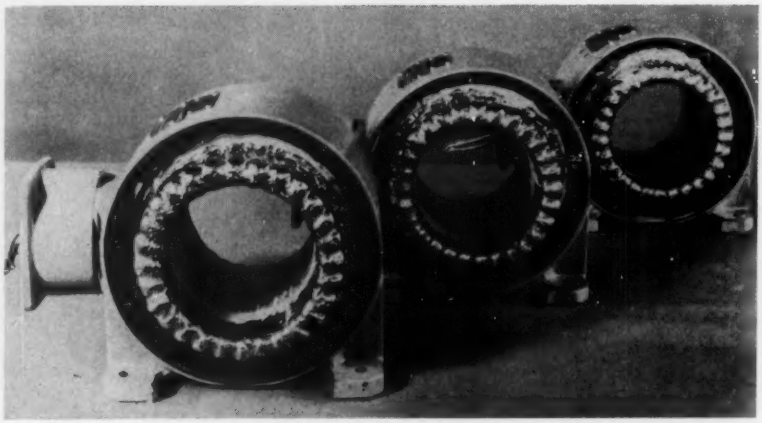
Circle 219 on Page 19

low and high speeds. One proposal calls for a wing that can be mechanically swept back to a delta configuration when the plane enters its high-speed regime.

Primary operational problem is the sonic boom, the report says. NASA is now organizing a research program to obtain detailed information on booms under various operational conditions. At subsonic speeds, the new plane will be no noisier than conventional jets.

Manufacturers estimate that production models of the transport should cost between $12.6 and $20 million each. There are widely varying estimates, however, of the possible market in the Free World at the time when the new jets would be available. Estimates ranged from 75 to 450 aircraft by 1968-75.

Stainless Foils Motor Corrosion



Encased in 0.002-in. thick stainless-steel foil, plastic-potted motor windings get effective, inexpensive protection against corrosion. The wrapping operation is relatively simple: Foil strips, joined with special adhesive, are fitted into place, leaving a small space between foil and windings. Epoxy resin is then poured into the gap, using a temporary mold to prevent rupture of the foil. Hardened resin forms mechanical support; tearing of the foil has not proved to be a problem. The process was developed by Epoxylite Corp., El Monte, Calif.

Meetings and Shows

Aug. 22-25—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon, 1435 S. La Cienga Blvd., Los Angeles 35, Calif.

Aug. 28-Sept. 1—

International Heat Transfer Conference to be held at the University of Colorado, Boulder, Colo. Sponsors are American Society of Mechanical Engineers and American Institute of Chemical Engineers; also participating are American Society of Refrigerating and Air Conditioning Engineers, Chemical Institute of Canada, Engineering Institute of Canada, Institute of the Aerospace Sciences, Society of Automotive Engineers Inc., and the University of Colorado. Papers will be presented by engineers from 13 countries. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Sept. 5-8—

Association for Computing Machinery. 16th National Conference and First International Data Processing Exhibit to be held at the

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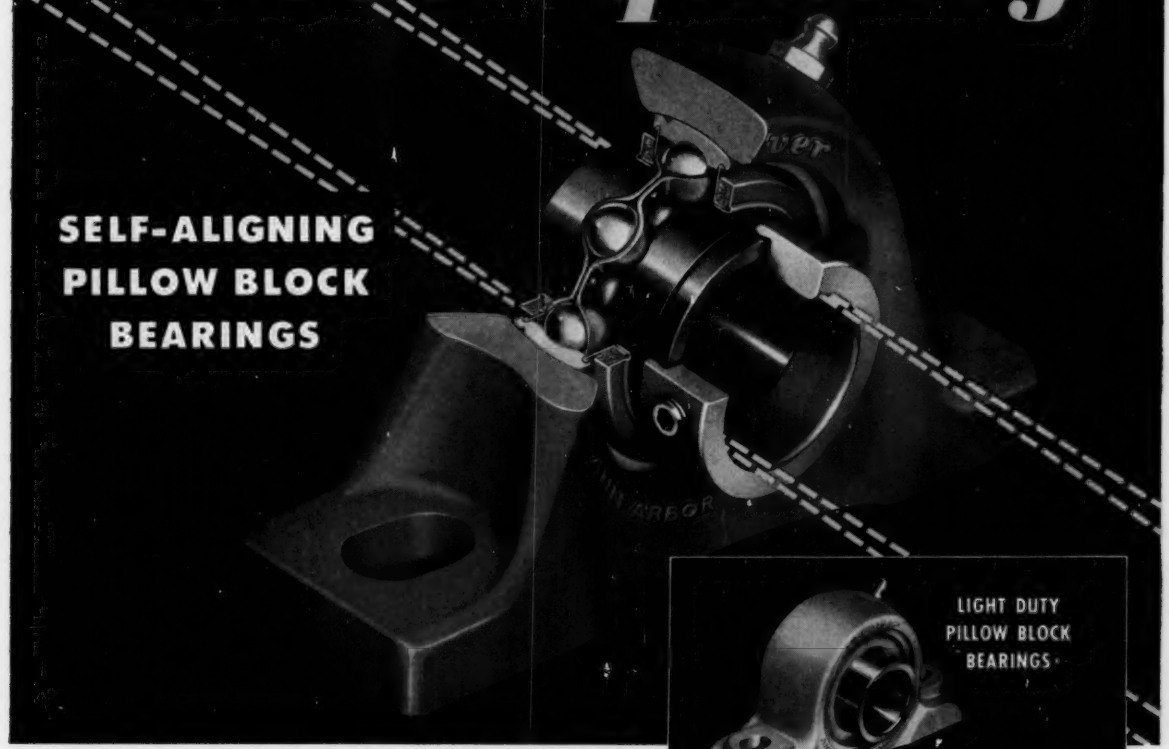
SELF-ALIGNING PILLOW BLOCK BEARINGS



LIGHT DUTY PILLOW BLOCK BEARINGS

ED Series meets requirements for quality made, economical units to carry light loads at normal speeds.

WITH *hoover-honed* RACEWAYS... *micro-velvet* BALLS

Hoover SP and SPH series pillow block bearings are designed for quick, easy installation. They are automatically self-aligning in any direction. The eccentric collar forms a self-tightening shaft lock. Elongated bolt holes in the base of the pillow block simplify mounting.

Hoover Quality bearing features assure long life and superior performance. *Hoover-Honed* raceways are super smooth, superbly finished. *Micro-Velvet* balls are accurate within millionths of an inch. Felt seals with metal shields retain factory applied lube and protect working surfaces from dirt.

Recommended for normal duty load conditions and shock, Hoover SP and SPH series pillow block bearings are available in shaft sizes from ¾" to 2 15/16".

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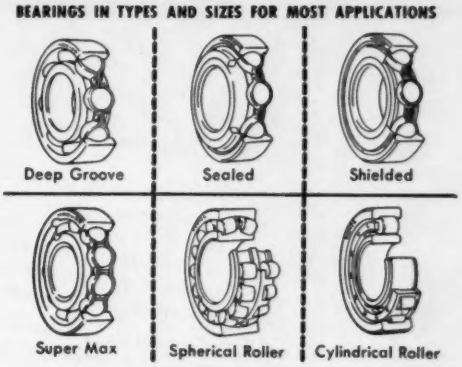

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Please send Bulletin 106 which describes Pillow Block Bearings.

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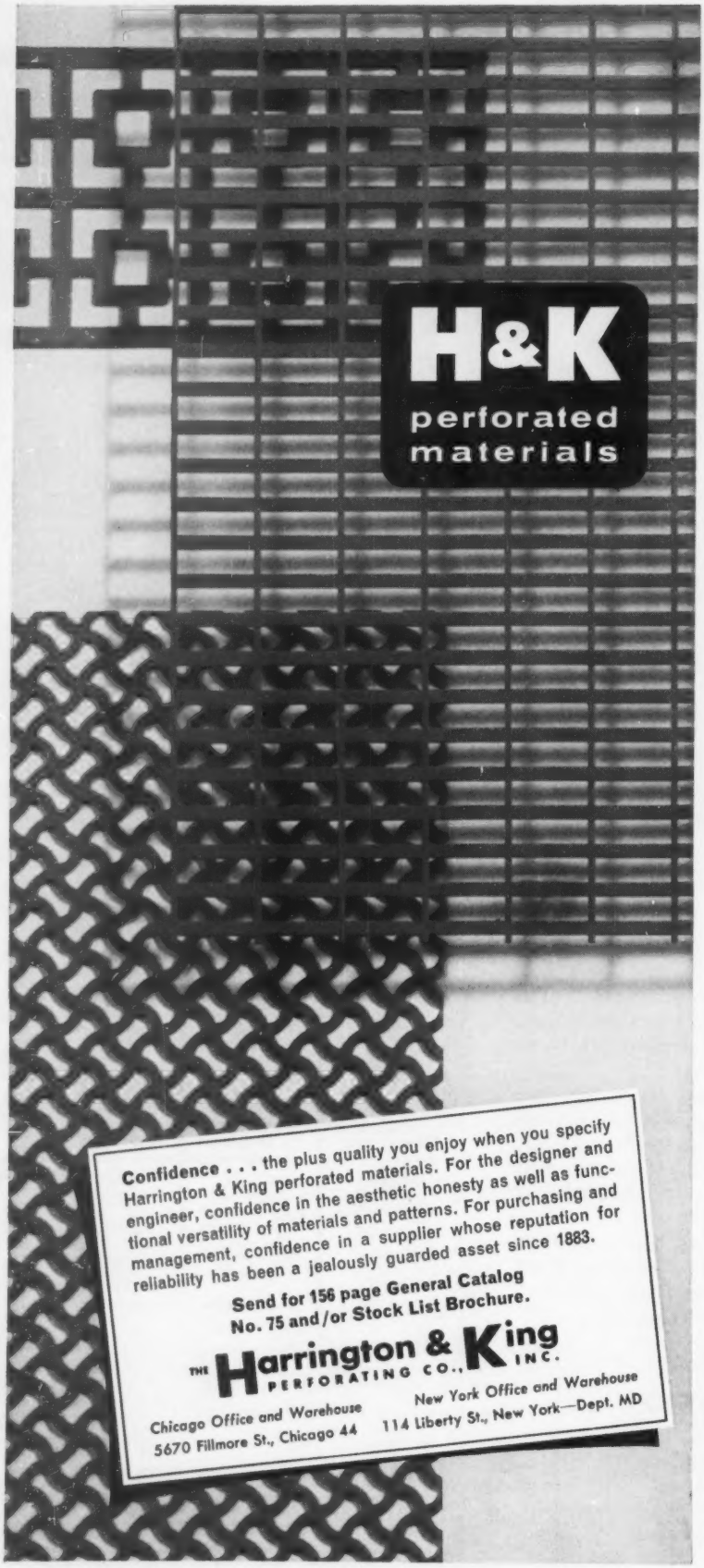
Circle 220 on Page 19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Statler-Hilton Hotel, Los Angeles. Further information is available from Benjamin F. Handy Jr., Litton Systems, 5500 Canoga Ave., Woodland Hills, Calif.

Sept. 11-14 —

Society of Automotive Engineers Inc. Heavy-Duty Vehicles Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Further information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 11-15—

Instrument Society of America. Sixteenth Annual Instrument-Automation Conference and Exhibit to be held at the Biltmore Hotel and Memorial Sports Arena, Los Angeles. Further information is available from Meetings Manager, ISA, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

Sept. 13-15—

Human Factors Society. Annual Meeting to be held at Ohio State University, Columbus, Ohio. Further information can be obtained from the society's executive secretary, Dr. Paul Cheatham, Engineering Psychology Branch, Office of Naval Research, Washington 25, D. C.

Sept. 14-15—

American Society of Mechanical Engineers - American Institute of Electrical Engineers. Engineering Management Conference to be held at the Roosevelt Hotel, New York. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Sept. 18-20—

Standards Engineers Society. Annual Meeting to be held at the Hotel Sherman, Chicago. Additional information is available from J. A. Caffiaux, executive secretary of SES, 11 W. 42nd St., New York 36, N. Y.

Sept. 24-27—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Muehlebach Hotel, Kansas

City, Mo. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 25-28—

Association of Iron and Steel Engineers. National Convention to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information can be obtained from society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 5-8—

American Society of Industrial Designers. Annual Meeting to be held at the Ambassador Hotel (Oct. 5). and the St. Catherine Hotel (Oct. 6-8), Santa Catalina Island, Calif. Additional information can be obtained from Richard M. Wilkes & Associates, 521 N. La Cienega Blvd., Los Angeles 48, Calif.

Oct. 9-11—

National Electronics Conference to be held at the International Amphitheatre, Chicago. Additional information is available from conference headquarters, 228 N. La Salle St., Chicago 1, Ill.

Oct. 9-13—

Society of Automotive Engineers Inc. National Aerospace Engineering and Manufacturing Meeting, including engineering display, to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 9-15—

American Rocket Society. Sixteenth Annual Meeting and Space Flight Report to the Nation to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Oct. 10-12—

American Standards Association. Twelfth National Conference on Standards to be held at the Rice Hotel, Houston. Further information is available from ASA headquarters, 10 E. 40th St., New York 16, N. Y.

Oct. 15-19—

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Sealing faces are precision-lapped to prevent stuffing box leakage. No break-in runs necessary. Positive drive feature eliminates all stress on bellows. This feature also permits the use of light spring load to minimize wear on sealing faces. Seal needs no attention over long periods of operation.

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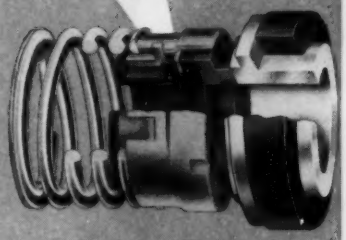

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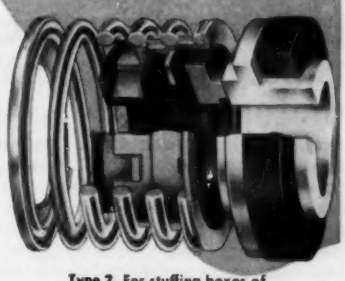

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Circle 222 on Page 19

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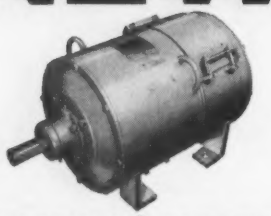

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Circle 223 on Page 19

Pulp and Paper Industry. Engineering Conference to be held at the Shoreham Hotel, Washington, D. C. Additional information is available from J. Winchester, 360 Lexington Ave., New York, N. Y.

Oct. 17-19—

American Society of Mechanical Engineers—American Society of Lubrication Engineers. Joint Lubrication Conference to be held at the Morrison Hotel, Chicago. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Oct. 19-20—

National Conference on Industrial Hydraulics to be held at the Sherman Hotel, Chicago. Additional information is available from Illinois Institute of Technology, 35 W. 33rd St., Technology Center, Chicago 16, Ill.

Oct. 23-27—

American Society for Metals. 43rd National Metal Congress and Exposition to be held at Cobo Hall, Detroit. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

Short Courses and Symposia

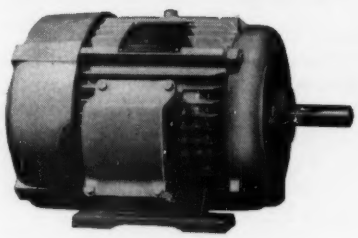
Sept. 5-9—

Short Course on Photoelasticity, to be held at the University of California, will review (by means of lectures, demonstrations, and laboratory exercises) the fundamental theory and laboratory techniques related to the classical applications of polarized light for solving stress problems. The most advanced techniques will also be discussed. Additional information can be obtained from Engineering Extension, Engineering Bldg. Unit II, Room 6266, University of California, Los Angeles 24, Calif.

Sept. 6-8—

Midwest Conference of Fluid and Solid Mechanics, to be held at Michigan State University, will present new research and development work in these two fields. Addition-

NEW



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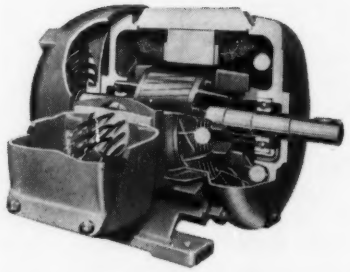

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al information is available from Dr. Joachim E. Lay, 14 Olds Hall, Michigan State University, East Lansing, Mich.

Sept. 6-8—

Joint Nuclear Instrumentation Symposium, sponsored by Instrument Society of America, American Institute of Electrical Engineers, and Institute of Radio Engineers, to be held at North Carolina State College, Raleigh, N. C. Additional information is available from Meetings Manager, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 11-22—

Institute on Experimental Stress Analysis, to be held at Wayne State University, will consist of Program 1—Photoelasticity, Theory and Application, and Program 2—Strain Gages, Theory and Application. Program 1 will include: Basic optics, the polariscope, birefringence, isoclinics and stress trajectories, study of separate stresses, model making and machining of photoelastic materials, and photoelastic coatings. Some topics for Program 2 are: Basic mechanics laws, strain - sensitive materials, properties and types of foil and wire gages, adhesives and modes of fastening, strain gage circuits, calibration, types of amplifiers, dynamic measurements, transducer application, and commercial equipment. Further information can be obtained from Dr. Joseph Der Havanesian, Institute Co - ordinator, Dept. of Engineering Mechanics, Wayne State University, 655 Merrick, Detroit 2, Mich.

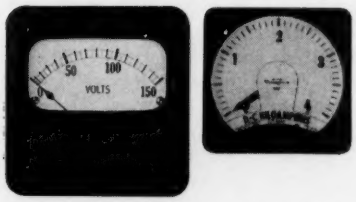
Sept. 12-15—

Seminar for Manufacturing Engineers to be held at Pennsylvania State University. It will cover latest techniques related to automation equipment development for engineers responsible for the design, installation, and operation of such equipment. Further information can be obtained from the Conference Center, Pennsylvania State University, University Park, Pa.

Sept. 20-21—

Industrial Electronics Symposium, sponsored by the American Insti-

NEW



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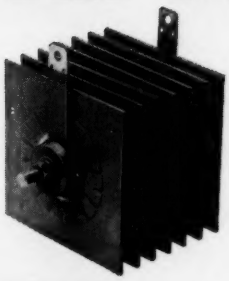

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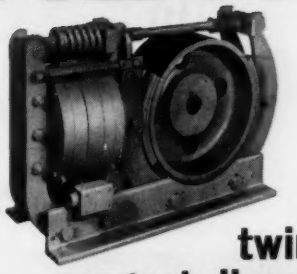

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tute of Electrical Engineers, the Professional Group on Industrial Electronics of the Institute of Radio Engineers, and the Instrument Society of America, to be held at the Bradford Hotel, Boston. Theme of the symposium will be supplier-user co-operation. Technical sessions will be on measuring techniques for industry, digital and analog techniques in industry, and new power conversion techniques. Additional information is available from D. J. LaCerda, Badger Mfg. Co., 363 Third St., Cambridge, Mass.

Sept. 27—

Seminar on Hydrostatic Transmissions, to be held at the Milwaukee School of Engineering, will be comprised of an introduction to the subject, design and analysis aspects, and typical applications. Mr. Frank Flick will speak on "Cylinder Design and Application Concepts" at a dinner following the seminar. Further information is available from Melvin E. Striegel, Director, Evening Div., Milwaukee School of Engineering, 1025 N. Milwaukee St., Milwaukee 1, Wis.

Oct. 25-26—

Computer Applications Symposium, sponsored by Armour Research Foundation, to be held at the Morrison Hotel, Chicago. Additional information is available from Benjamin Mittman, program chairman, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

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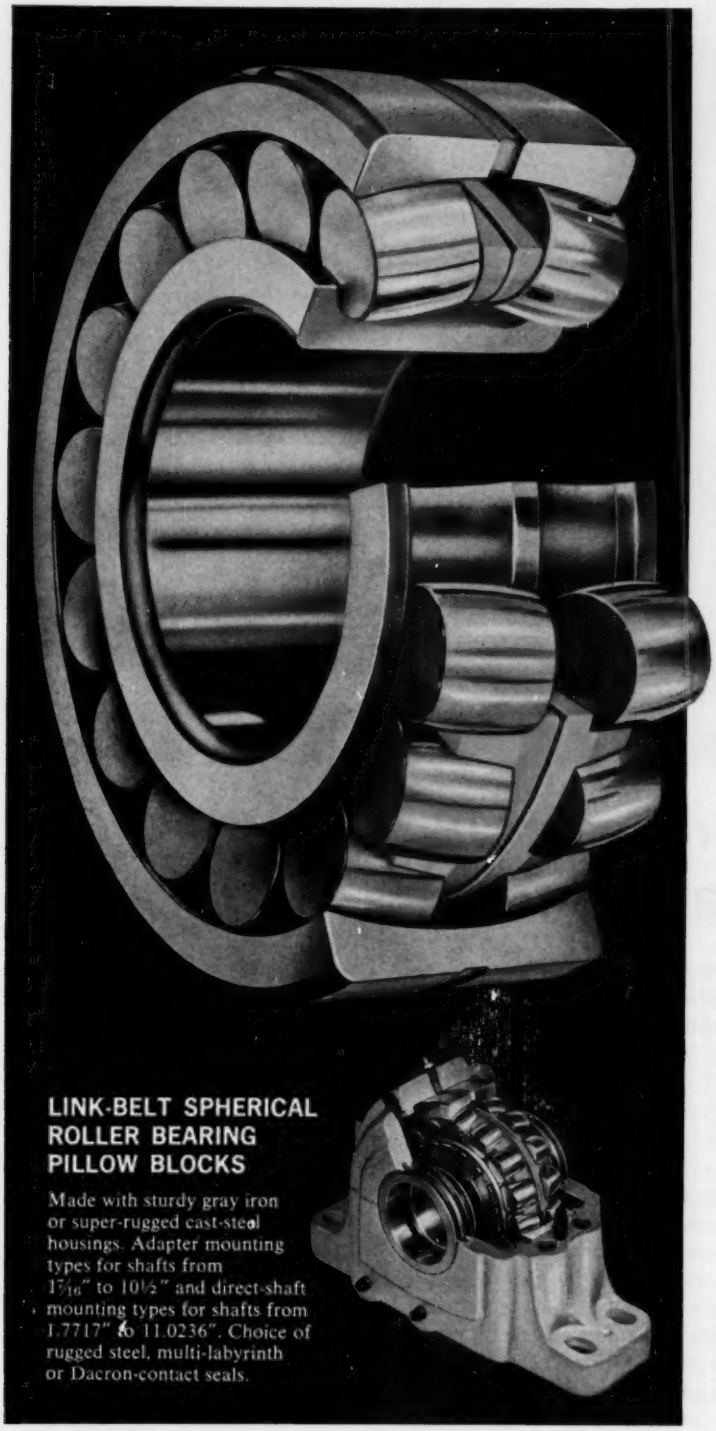
LINK-BELT SPHERICAL ROLLER BEARINGS:

measure these design values in terms of your applications



LINK-BELT SPHERICAL ROLLER BEARING PILLOW BLOCKS

Made with sturdy gray iron or super-rugged cast-steel housings. Adapter mounting types for shafts from 1 7/16" to 10½" and direct-shaft mounting types for shafts from 1.7717" to 11.0236". Choice of rugged steel, multi-labyrinth or Dacron-contact seals.

GREATER CAPACITY!

The reason? *More rollers, larger rollers!* Bearing capacity depends primarily on effective roller Length, roller Diameter and Number of rollers (L x D x N). And Link-Belt offers the *largest effective roller complement* for all sizes of spherical roller bearings . . . rated according to accepted formulas of the Anti-Friction Bearing Manufacturers Association. This increase in LDN values provides extremely high capacity . . . and in users' evaluation, it adds up to far longer bearing life.

GREATER DURABILITY!

With balanced proportion design, Link-Belt spherical roller bearings possess durability characteristics that exceed the bearing industry's exacting requirements. Optimum balance of rollers, inner and outer rings must be obtained for increased bearing capacity . . . yet overall bearing dimensions must conform to an established international standard boundary plan.

Wrap-around, completely contoured retainers also contribute to durability through positive roller guidance and spacing. Precision-machined of centrifugally cast bronze, these husky retainers are far stronger than stampings or sand castings.

GREATER PRECISION!

Link-Belt spherical roller bearings are made in the world's most modern bearing plant . . . with the most-advanced tools and techniques known to industry. A rigid quality control program leaves *nothing* to chance. Each Link-Belt bearing is subjected to *758 actual inspections*. Microsmoothness and precision are continuously scrutinized by automatic machines. Result: these bearings have been specified by leading manufacturers of cranes, shovels, graders, vibrating screens, and steel mill, paper mill and foundry equipment . . . and for high-precision applications such as embossing rolls, printing presses and torque converters.

SEE BOOK 2760 for further precision, durability and high-capacity features. Contact your nearest Link-Belt office. Look under BEARINGS in the Yellow Pages of your phone book.

LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,682

SIMPLE AS A·B·C
A. Operator inserts microfilm aperture card.
B. Next, inserts sheet of ordinary paper, vellum, or offset paper master. Insertion starts automatic printing and processing cycle.
C. First print is automatically delivered in 30 seconds; subsequent prints (of the same or different drawings) every 15 seconds.

From microfilm to an 18″x 24″ print ...in seconds and on ordinary paper!

You can have a dry, positive, 18″x24″ engineering print in seconds and on ordinary paper with the new 1824 Printer.

This remarkable machine, which requires no exposure settings or other adjustments, reproduces from a microfilm aperture card, making 18″x24″ prints—or smaller—at extremely low cost. It also copies onto vellum or offset paper masters.

Operation is automatic. Prints ready for immediate use emerge as fast as four a minute.

The quality of reproduction is superb. Images are sharp black-on-white and won't rub off. There is no odor, no waste, and the finished print may be written on with pen or pencil.

Regardless of your engineering-drawing-reproduction needs, you can now enjoy the tremendous savings in time, money, space, and materials of your own unitized microfilm system.

Formerly, such economies required a substantial reproduction need. Today, however, the 1824 Printer offers the same proportionate benefits to small-volume users as to large. No need now for vast files of engineering drawings. Microfilm aperture cards require only a fraction of the storage space rquired for other reproducibles. No more costly waiting for prints, which—made by an 1824 Printer—are so inexpensive your engineers can discard them after use.

Write today for our free 1824 booklet giving the full benefits you can expect from an 1824 Printer. XEROX CORPORATION (formerly Haloid Xerox Inc.) 61-260X Haloid St., Rochester 3, N. Y. Branch offices in principal U.S. and Canadian cities. *Overseas:* Rank-Xerox Ltd., London.

XEROX
CORPORATION

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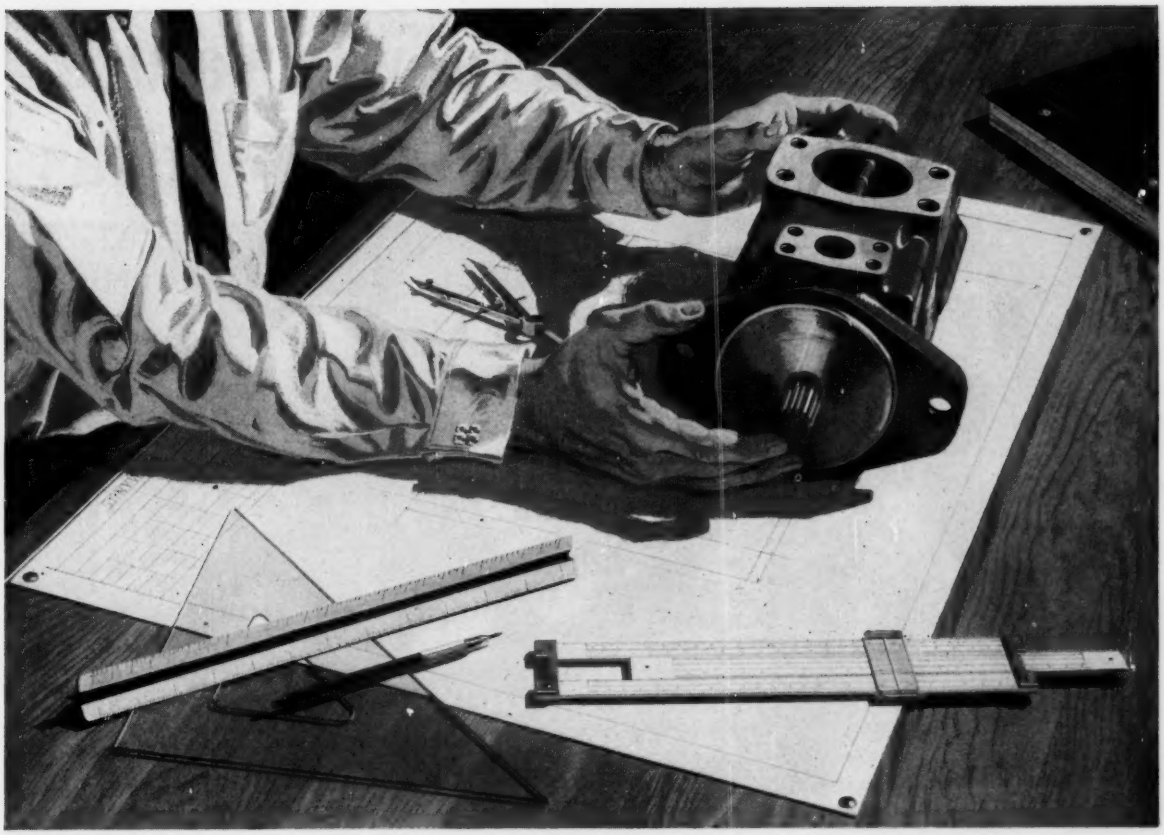
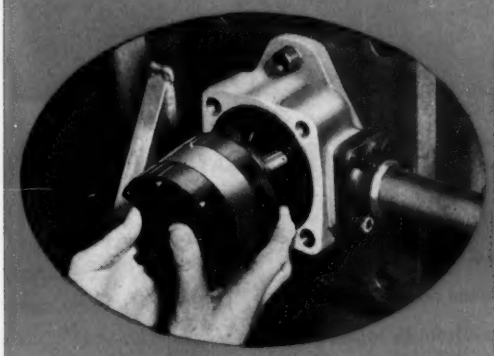


IF YOU BUILD MOBILE EQUIPMENT...

VICKERS WILL MATCH A PUMP TO YOUR APPLICATION



10 minute field repair

Typical of the advanced design features available on Vickers pumps is the replaceable pumping cartridge in the "High Performance" series. A complete overhaul: cover removal, cartridge replacement, and cover replacement takes just 10 minutes in the field—no critical fitting or adjusting!

Customized designs or standard models—both are available from Vickers. Industry's broadest line of mobile pumps allows you to select the design that's best for you . . . saves you from paying for "too much" pump and from getting "too little".

Our application engineers can help you match your specifications with one of several thousand standard combinations of single or double pumps with choices of shafts, mountings, port connections, deliveries and direction of rotation. However, when unusual requirements demand special approaches, Vickers unequaled Research and Development facilities are at your service.

Whichever type of pump you select, wherever your equipment goes, there is the additional advantage of complete interchangeability of parts built in any Vickers plant located throughout the free world, providing full service coverage.

Additional data on pumps for mobile applications is available from your Vickers application engineer or by writing to address below. Ask for Bulletin P1.

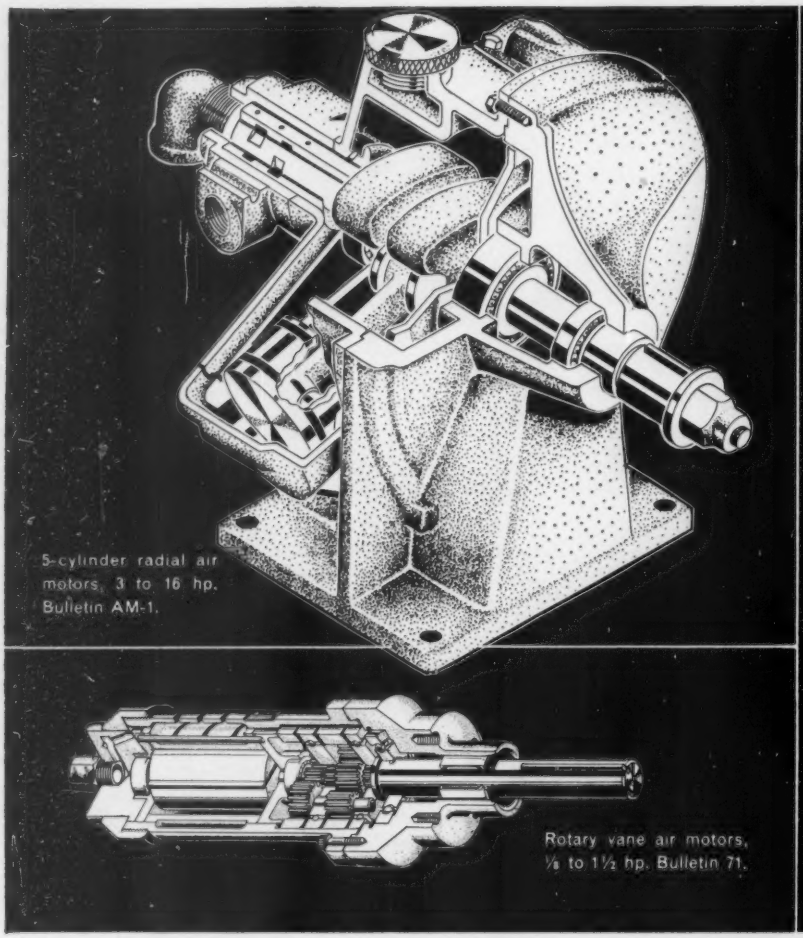
VICKERS®

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE AND ENGINEERING CENTER
DETROIT 32, MICHIGAN

9461

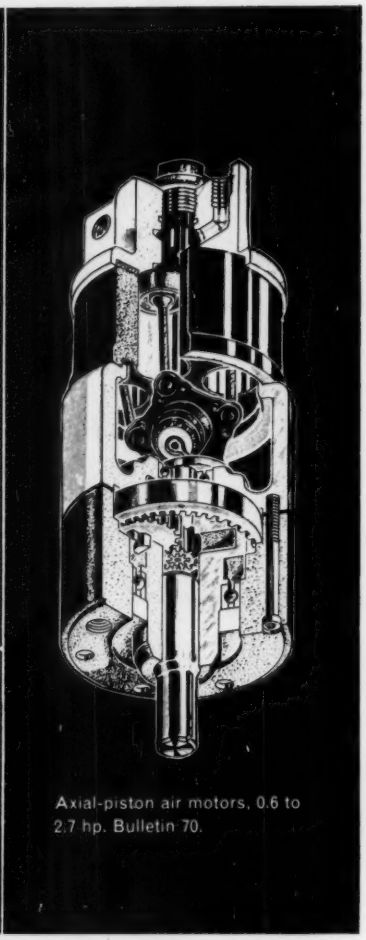
Circle 233 on Page 19

When you analyze power values, look to air power for new ideas



5-cylinder radial air motors, 3 to 16 hp. Bulletin AM-1.

Rotary vane air motors, ⅛ to 1½ hp. Bulletin 71.



Axial-piston air motors, 0.6 to 2.7 hp. Bulletin 70.

MEET ALL THESE POWER NEEDS

- High starting torque
- Reversibility without power loss
- Variable speed, easily controlled
- Cool operation
- Instantaneous starts and stops
- Consistent torque output
- Spark-resistant characteristics
- Thrust or axial spindle loads
- Enclosed construction
- Output from ⅛ to 16 hp

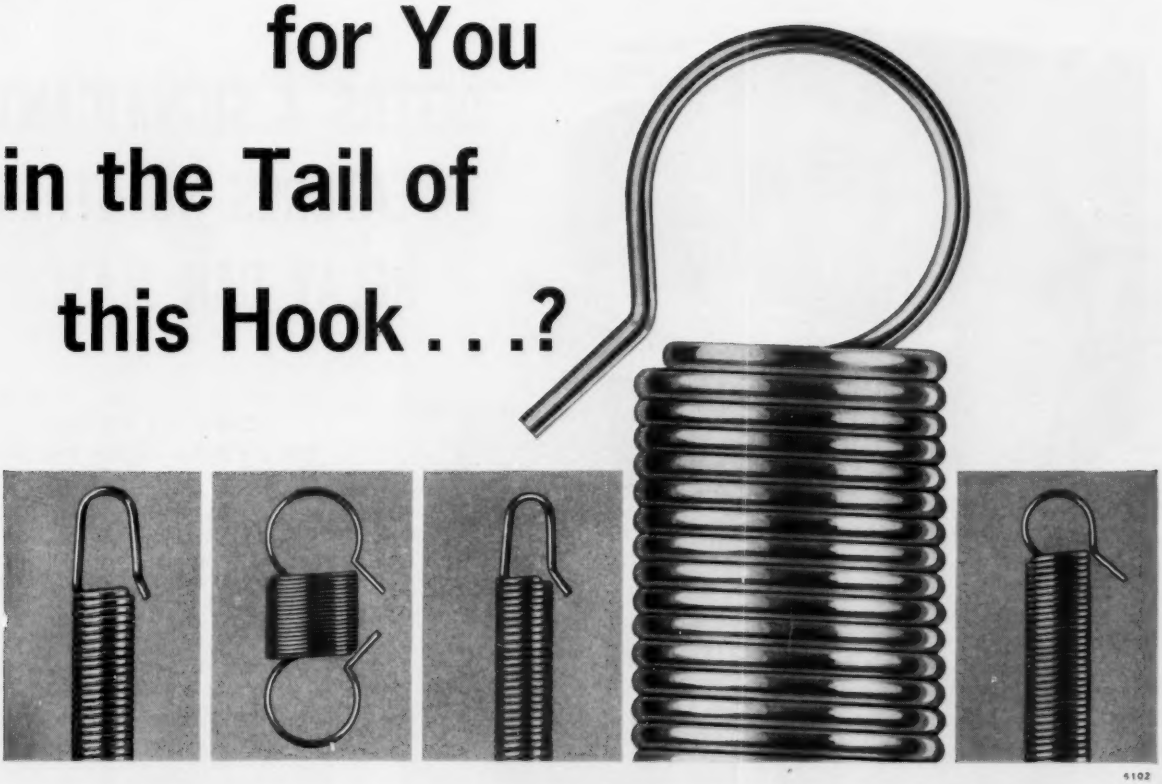
Your Gardner-Denver specialist will be glad to consult with you in putting air power to work in your new designs.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois—Offices in principal U. S., Canadian and Mexican cities. In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario. International: Gardner-Denver International Division, 233 Broadway, New York 7, N. Y. International Offices: Buenos Aires, Argentina; Artarmon, N. S. W. Australia; Brussels, Belgium; Rio de Janeiro, Brazil; Santiago, Chile; Barranquilla, Colombia; Lima, Peru; Ndola, N. Rhodesia; Salisbury, S. Rhodesia; Johannesburg, Transvaal.

Is There a Happy Ending for You in the Tail of this Hook . . .?



5102

Installation of small extension springs in restricted space was a problem in assembling business machines. Also plagued with the same problem were field servicemen. Development of Easy-on® Hooks provided the happy ending to both situations—opened up new possibilities for wider application.

Shown above are variations of the Easy-on® principle—production-formed extended lips which make it possible to snap on or off the anchoring point with ease. Easy-on® Hooks may be formed at either or both ends. Springs can be provided with Lock-on® hooks also advantageous in certain operating conditions.

Here's a typical example of A.S.C. service that is your best buy in spring-making. Helping to achieve cost-saving efficiencies in design, use, or production of springs, wire forms, small stampings is the specialty of all A.S.C. Divisions. May we discuss your requirements?

Write for "How A.S.C. solves design and production problems of Springs and Spring-like things."

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Merchandise Division, Corry, Penna.
Raymond Manufacturing Division, Corry, Penna.
Cleveland Sales Office, Cleveland, Ohio
Chicago Sales Office, Chicago 46, Ill.
Ohio Division, Dayton, Ohio
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Mattoon, Ill.
Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.
Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.

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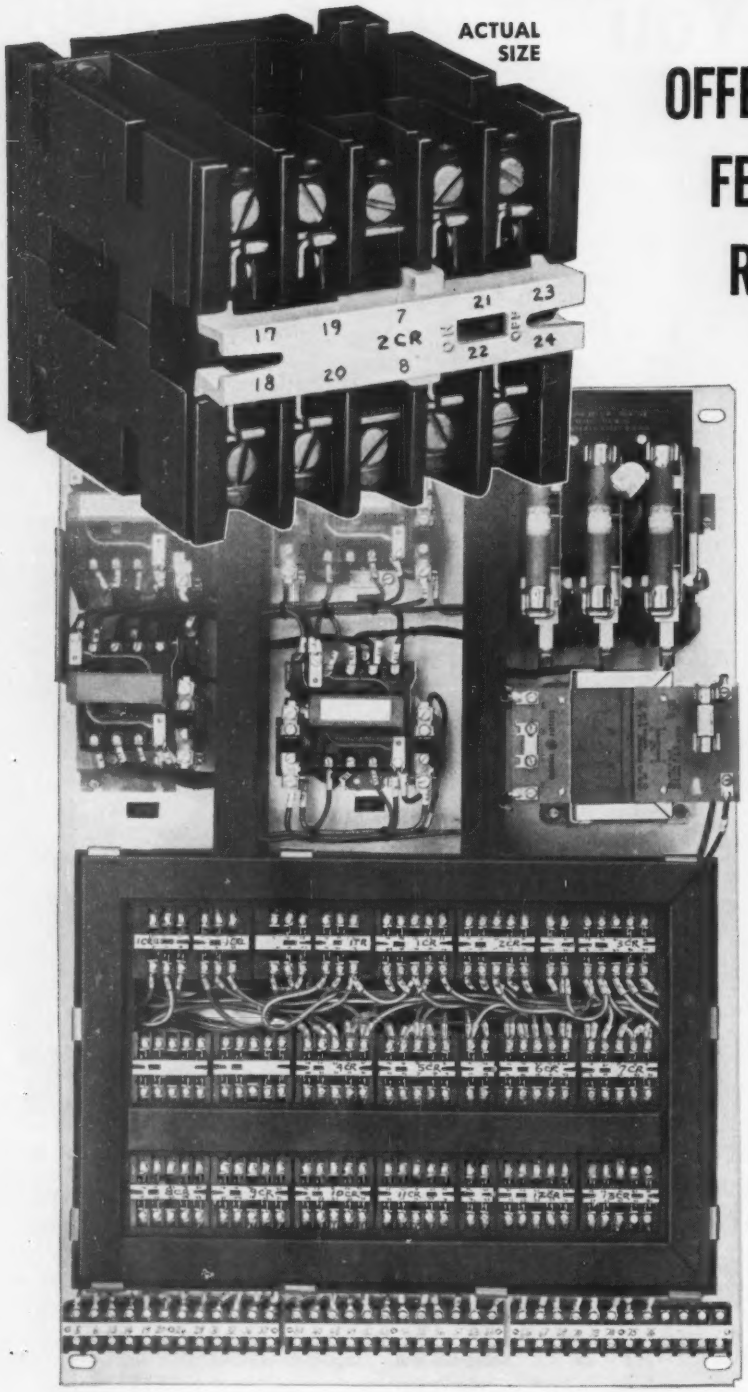
NEW General Electric 10-amp,



OFFERS 4 SIGNIFICANT FEATURES NO OTHER RELAY CAN MATCH!

1. *ONLY* 300-VOLT RELAY WITH CONVERTIBLE CONTACTS

You can change contacts from normally open to normally closed in 90 seconds . . . with only a screwdriver. Coils too, can be changed in seconds . . . and you can make up any form you need through 8 poles from basic 4-pole relay. Result: increased flexibility, reduced inventory costs.

2. *ONLY* 300-VOLT RELAY TO FORM ITS OWN WIRING TROUGH

New CR120 relays eliminate need for separate wiring trough—require only 5⅝ square inches of mounting area. Result: panel size is substantially reduced because you can mount more relays in a given space.

3. *ONLY* 300-VOLT RELAY WITH ALL TERMINALS OUT-IN-FRONT

There's no double-decking of terminals to complicate hook-up. Wiring and maintenance are simple because *all* terminals are out-in-front where they are most accessible. Result: important savings in installation and maintenance time and costs.

4. *ONLY* 300-VOLT RELAY OFFERING ALL THESE FORMS

Choose from standard 2-, 4-, 6-, and 8-pole relays and latched and pneumatic timer forms. Also available are 2-pole adder kits, allowing you to assemble 6- and 8-pole relays from basic 4-pole form.

Your General Electric sales engineer has a sample of this new 300-volt relay. Call him today for a demonstration. Or, write for publication GEA-7329, General Electric Co., Section 811-26, Schenectady 5, New York.

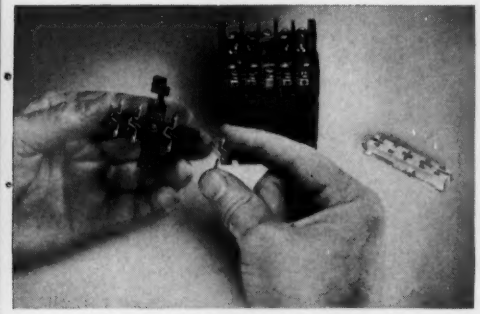
Progress Is Our Most Important Product

GENERAL ELECTRIC

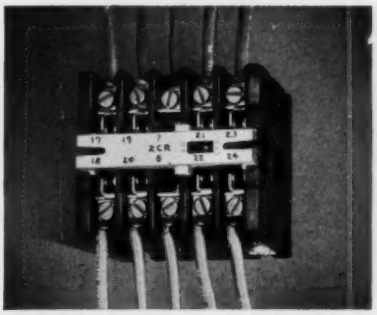
SNAP-IN TROUGH COVER between top and middle rows of relays (on lower half of panel above) has been removed to show how relay sides form own wiring trough. Space-consuming wiring trough is eliminated, and relays can be mounted closer together.

300-volt industrial relay...

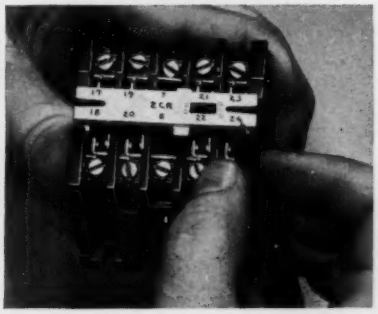
Save Panel Space, Installation Time With These Design Features



90-SECOND CONTACT CHANGE—Convertible contacts may be changed from normally open to normally closed with only a screwdriver . . . in the field. Allows you circuit flexibility, reduces your relay inventory.

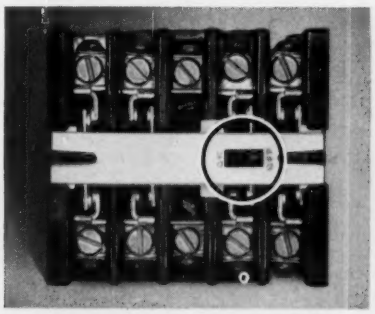


ALL TERMINALS IN FRONT—Have terminal-board accessibility—no need for double-decking . . . even on 8-pole forms. Result: *complete* accessibility from the front means installation time is greatly reduced.

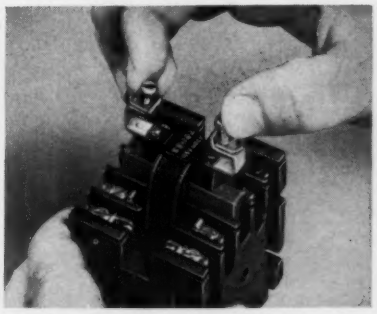


HANDY WRITE-ON MARKING STRIP—White nylon marking strip lets you label each relay and all wires. Result: visual identification of relay and wire numbers saves time when inspecting or trouble shooting.

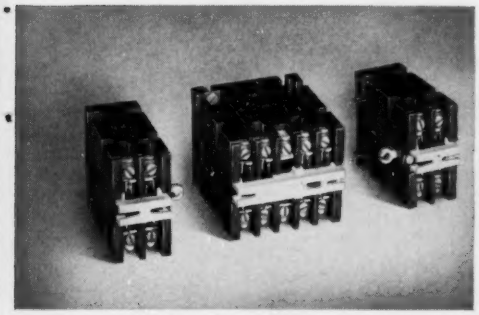
WIDELY-SPACED TERMINAL BARRIERS—Plenty of space between terminal barriers (⅜ inch) allows you easy access with standard screwdriver for connecting leads. Large pan-head screws add to ease of hookup.



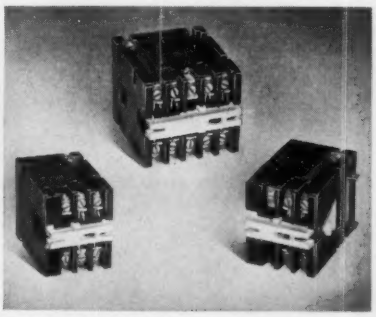
VISIBLE CONTACTS—All contacts are visible at a glance. You can check panel functions manually by moving indicating tab. ON-OFF identification on marking strip indicates whether or not coil is energized.



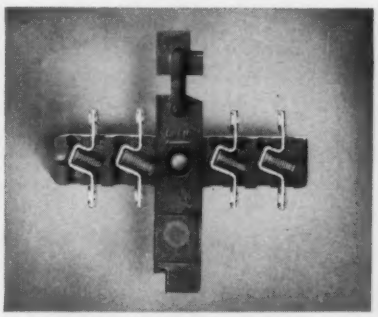
30-SECOND COIL CHANGE—Inspect or replace coil by loosening two screws and pulling out coil. Can be done without the use of special tools . . . and without removing the relay from the panel.



BUILDING BLOCK POLE-ADDERS—Two-pole adders can be mounted on sides of basic relay to give 6- or 8-pole device. Allows you building-block flexibility . . . in the field. All forms also available from factory.



COMPATIBLE DESIGN FOR ALL FORMS—Same design used for latched relays, relays and timer (1 to r). Height, wiring arrangement, and terminal locations are alike for all forms. Result: simplified installation.



HIGH CONTACT FIDELITY—Self-cleaning contacts have unique "scrubbing" action. Movable contact springs are mounted at an angle so contacts slide over each other to wipe off contaminants.

GENERAL ELECTRIC

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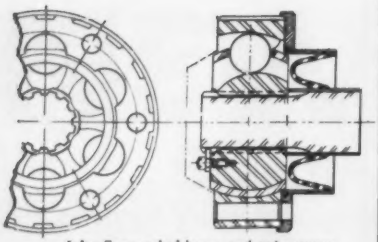
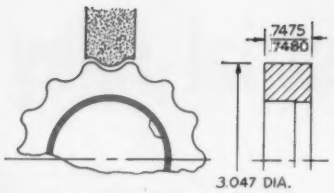
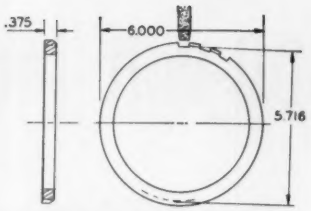


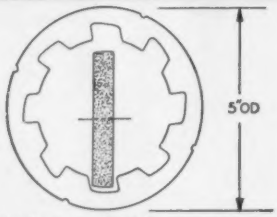
Job: Form grind inner and outer races and grooves and slots in ball cage of constant velocity universal joints.



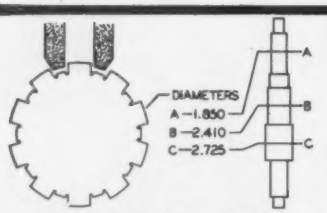
Job: Contour grind 14 lobes
Part: Pump rotor
Output: 88/hr, floor to floor
Material: Steel 200 Brinell
Pcs/load: 12



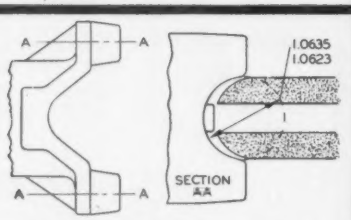
Job: Grind 24 teeth from solid
Part: Splined spacers
Output: 18/hr
Material: Steel
Pcs/load: 9



Job: Contour grind internal cams
Part: Roller clutch cam
Output: 60/hr
Material: Case hardened steel
Pcs/load: 2



Job: Straddle grind 3 sets of 10-splines (parallel sides)
Part: Transmission mainshaft
Output: 2.7/hr/spline set
Material: Steel 61-64 Rc
Pcs/load: 1

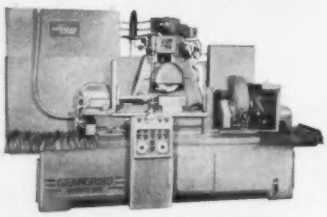


Job: Grind 2 half-rounds from rough
Part: Universal Joint
Output: 400/hr, floor to floor
Material: Pearl. Mall. Iron
Pcs/load: 10

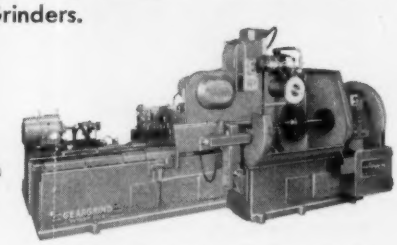
Now You Can Design for FULLY AUTOMATIC FORM GRINDING

to cut costs, improve accuracy on external and internal contours

Here are some examples. You now have greater freedom of design for all kinds of internal and external forms with assurance of top accuracy using versatile standard and special Detroit Automatic Grinders.



"Detroit" automatic contour grinder for up to 20" PD.

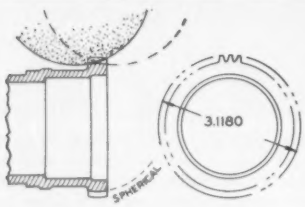


"Detroit" automatic contour grinder for up to 36" external and 30" internal.

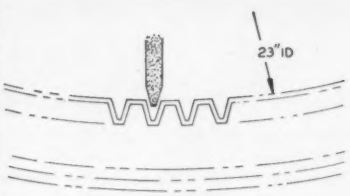
GEAR GRINDING MACHINES DIVISION

MICHIGAN TOOL COMPANY

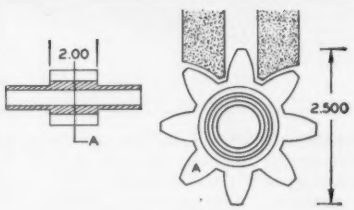
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN



Job: Spherical grind 48 teeth
Part: Spherical gear coupling
Output: 2.3/hr
Material: Carburized 60 Rc
Pcs/load: 1



Job: Internal grind 157 teeth
Part: Aircraft reduction gear
Output: 1.2/hr
Material: Case hardened
Pcs/load: 1



Job: Straddle grind 8 teeth
Part: After-burner pump gear
Output: 11/hr, floor to floor
Material: Nitrided steel 15N-90
Pcs/load: 1

Circle 237 on Page 19

Look to

FAFNIR

for leadership in ball bearings

Where cost is your problem...

Costs can nip good design ideas in the bud. Fafnir helps cut costs with Flangette Units. Millions of these ball bearing "economy packages" — a Fafnir "first" — are used to improve performance and reduce maintenance on products ranging from small conveyors to giant combines. When you're up against costs... or *any* bearing problem... look to Fafnir. The Fafnir Bearing Company, New Britain, Connecticut.

50 YEARS OF EXPERIENCE
IN THE MANUFACTURE OF
BALL BEARINGS

FAFNIR
BALL BEARINGS

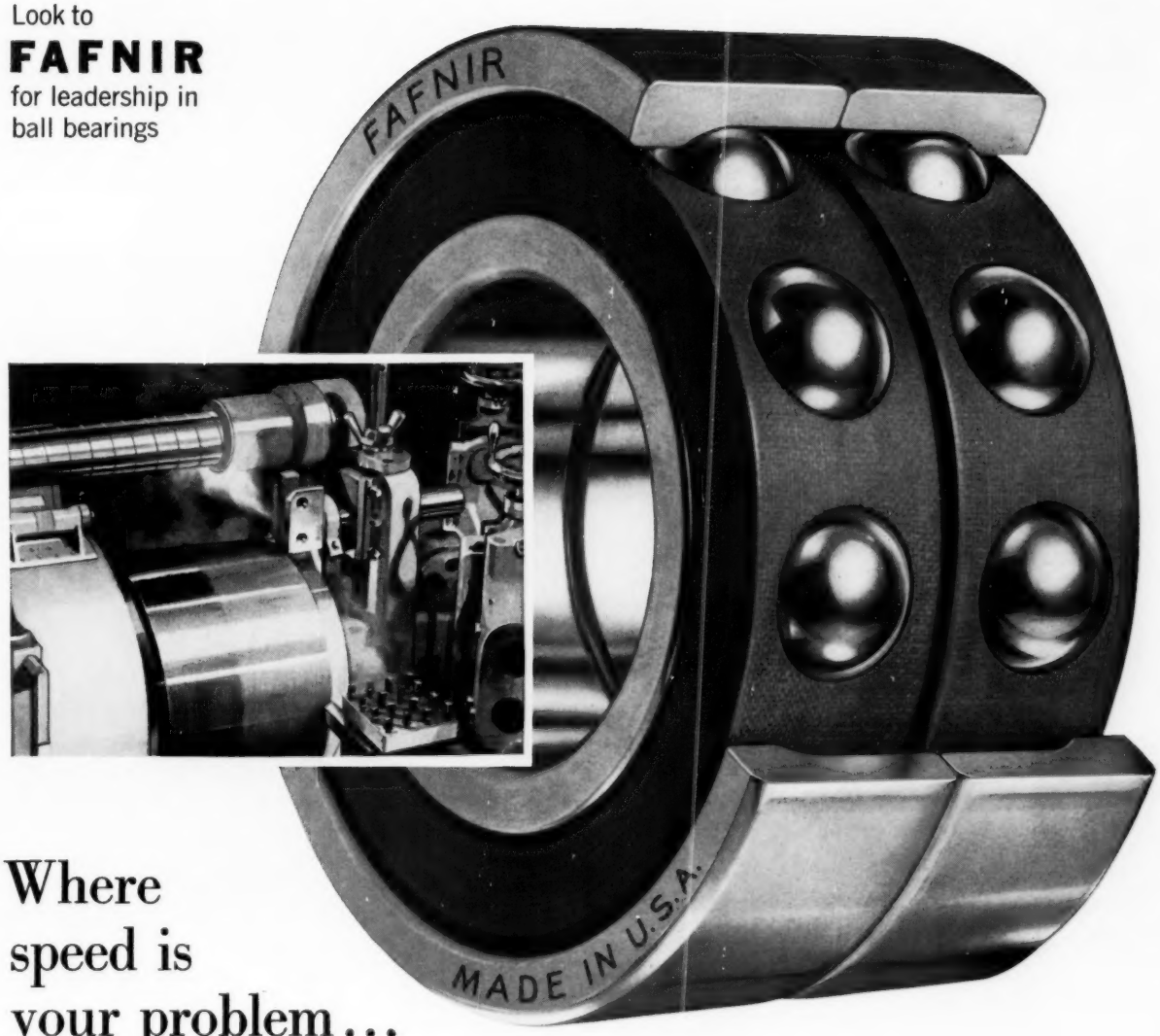
Look to
FAFNIR
for leadership in
ball bearings

Where dirt is your problem...

Dirt is cheap . . . but not when it gets into bearings. It handicaps production . . . runs up costs . . . shortens product life. How to keep dirt out? Disc harrow makers do it with Fafnir Ball Bearings . . . triple-sealed to "run clean" where it's dirtiest. When you're up against dirt . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, the research to find your answer. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

Look to
FAFNIR
for leadership in
ball bearings



Where speed is your problem...

Today's high speeds put the spotlight on bearings. For when bearings fail, costs rise . . . and profits drop. Machine tool builders know this. That's why they specify Fafnir Ball Bearings for high speed applications — 100,000 rpm and up. So, when you're up against speed . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, and the research to find your answer. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

Look to
FAFNIR
for leadership in
ball bearings

Where heat is your problem...

Some bearings "freeze" under prolonged high heat. When they do, performance drops off . . . costs rise . . . and the heat's on *you!* The answer? Fafnir Ball Bearings engineered for high temperature service. For instance, in the X-15 manned rocket, they're used by the hundreds at critical points. So, when you're up against heat . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, the research to find your answer. The Fafnir Bearing Company, New Britain, Connecticut.

"MADE IN U. S. A."

This stamp on a Fafnir Ball Bearing means finest quality and workmanship . . . dependable supply . . . competent engineering help . . . and **responsibility** in meeting your bearing needs. It's worth bearing in mind.

FAFNIR
BALL BEARINGS

SILICOLOGY

Studies in Silicones

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

Silicone Rubber Compounds Designed To Put Bounce in Appliance Sales

Design engineers in the appliance field have to look two ways at once. Toward sales: What the customer wants. Toward production: Costs, handling, assembly, dimensional accuracy, reliability.

CUSTOMER IS ALWAYS RIGHT

They must also recognize past customer complaints. Thus an otherwise splendid kitchen range may have required frequent cleaning because of vapor stains that leaked past the oven door. But no ordinary rubber gasket can stand oven temperatures without cracking and giving off offensive fumes. And without gaskets, tightly fitting oven doors are a production nightmare. What does the designer do?

To meet such a situation, special silicone rubber compounds based on Union Carbide masterbatches and gums have come to his rescue, not only for oven gaskets but for practically every spot in home appliances where the properties of ordinary rubbers are inadequate.

WHERE YOU BENEFIT

You or your fabricator can mold these materials with minimum effort and top economy. One economy compound, for instance, has tensile strength of 750 psi and elongation of 150%. Another has 900 psi tensile, 250% elongation. And a premium compound, K-1347 for highly critical applications, has 1400 psi tensile and 425% elongation. Other important properties are low compression set, oil resistance, water resistance. And of equal importance on the production line is extrudability such that accurate dimensions and unvarying sharp edges are assured.

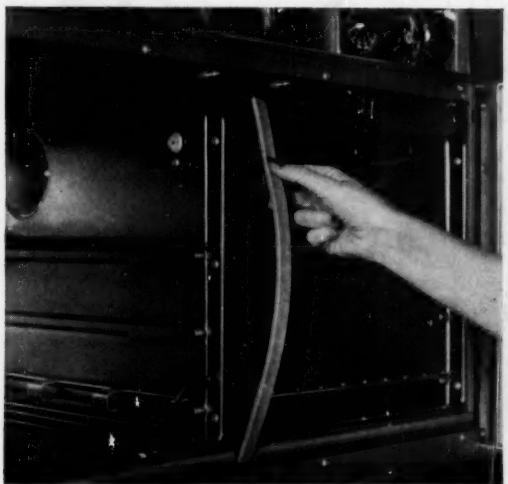
To get back to oven doors, gaskets can now withstand broiling temperatures, yet seal in heat, save BTU's, keep stoves cleaner, reduce smoky kitchen air and... well, you've got some pretty strong sales promotion material right there!

BROADEST EXPERIENCE AVAILABLE

Since silicone rubber gaskets also stay flexible when very cold, they're excellent for refrigerator doors. Moreover, silicone rubber's combined heat and electrical resistance and easy extrudability make it an ideal electrical insulating material for hot-appliance wiring.

One such application is on the automatic defroster wire in the new refrigerators. High temperatures in confined spaces would quickly affect ordinary materials, but silicone rubber retains its properties at both ends of the thermometer. Also in refrigerators, you'll find that the tubing that carries moisture away from defroster units is more serviceable if made of silicone rubber.

There are countless ways silicones can help you design better quality into your products and your processes. Your UNION CARBIDE Silicones Man is at your service. Behind him is not only his own know-how, but the vast experience and research of the parent Union Carbide Corporation in virtually every field of industry. For information and help, fill in the attached coupon and mail it today.



Grease-repellent, heat-resistant oven door seal of the Tappan Co.'s range is extruded from Silicone Rubber compound made from a UNION CARBIDE base material. Always-tight seal slips out for wiping. Made by Acadia Synthetic Products, Chicago 23.

NEW SILICONE RESIN FOR HIGH-TEMPERATURE ENAMELS

UNION CARBIDE R-621 Silicone Resin has just been announced for use in straight silicone enamels for appliance finishes where mar-resistance and resistance to "hot tack" at elevated temperature are required. With nonmetallic pigments, it may be used at temperatures up to 500 deg. F., with excellent gloss and color retention and resistance to organic solvents and greases. With metallic flake pigments, it may be used up to 1200 deg. F.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. LH-9103
30-20 Thompson Ave., Long Island City 1, N.Y.

In Canada: **Union Carbide Canada Limited, Bakelite Division, Toronto 12.**

Please send me data on UNION CARBIDE Silicone Rubber and on _____

_____

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Circle 251 on Page 19

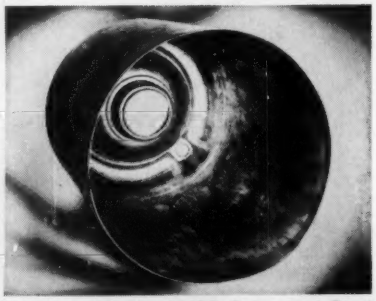
LI'L ABNER by Al Capp

about USS Galvanized Steel

A TRIPLE-FLUTED OCTAGONAL-SIDED, LEFT-HAND EXHAUST DUCT!!—YO' KIN EASY WHOMP IT UP, WIF THEM USS GALVANIZED STEEL SHEETS!!
RIGHT!!—AH KIN MAKE ANYTHING WIF IT!!—AN' WE SHORE NEEDS THET DUCT-WORK, AS ANY FOOL KIN PLAINLY SMELL!!
BIG BARNSMELL'S "FLEUR DE SKONK" 'LL NEVAH EAT THROUGH THESE CORROSION-RESISTANT CONTAINERS, MADE OUTA USS GALVANIZED STEEL SHEETS!!
© United Feature Syndicate, Inc.
Al Capp

Here's proof that USS Galvanized Steel Sheets have exceptional workability—twist and bend, and the zinc coating won't flake off.

USS Galvanized Sheets make excellent duct-work. They're strong and rigid. Lock joints stay tighter. Installation is quick and easy.

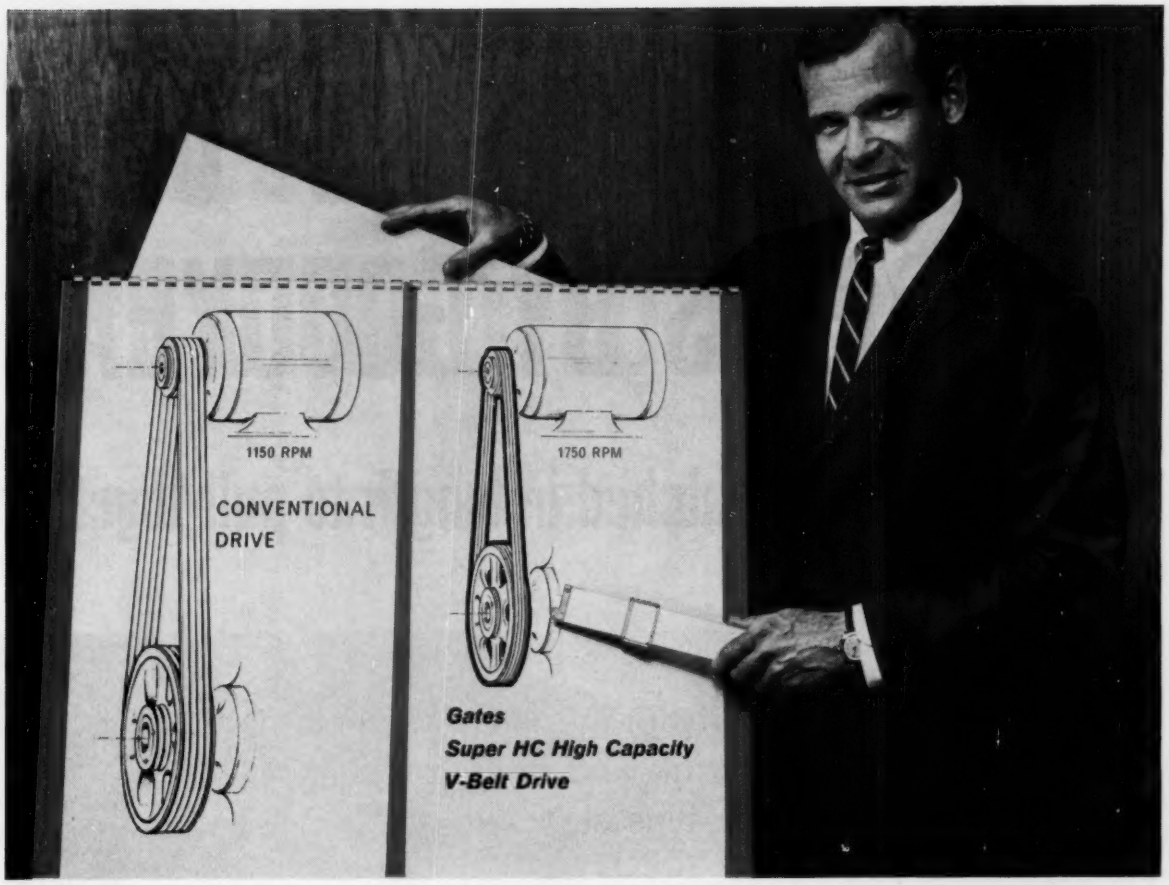


This "container" of USS Galvanized Steel illustrates the outstanding formability and drawing characteristics of the metal.

United States Steel Corporation • Columbia-Geneva Steel Division
Tennessee Coal and Iron Division • American Steel and Wire Division
United States Steel Supply Division • United States Steel Export Company.

USS TRADEMARK

United States Steel



How Gates Super HC Drives can save space, weight, money on the machines you design

Ask your local Gates Man to design a drive for your machine two ways: A conventional V-belt drive and a Gates Super HC High Capacity Drive. A quick comparison will show you that the new Gates Drive costs up to 20% less than a conventional V-belt drive, weighs about 20% less and can handle your power requirement in ⅔ to ½ the space.

These advantages are possible because of exclusive, basic changes in V-belt shape and construction that permit this drive to transmit up to 3 times the horsepower of a conventional V-belt drive in the same space.

Manufacturers everywhere have standardized on the Gates Super HC Drive—the first and most advanced High Capacity Drive. It is your best assurance that your power transmission unit will remain up-to-date for many years to come.

The Gates Man, located near you, has had long, intensive training and experience in drive design. *Contact him for complete technical data on Gates Super HC High Capacity Drives and for expert drive design aid.*

The Gates Rubber Company, Denver, Colorado

BP54

Gates Super HC Drive Gives you these benefits:

- Saves up to 50% in drive space.
- Reduces drive weight 20% and more.
- Cuts drive costs as much as 20%.
- Reduces bearing load, increasing bearing life.
- Guards can be smaller, lighter weight.
- Belt speed up to 6000 ft/min possible without dynamic balancing.
- Less costly, higher speed motors can often be used.
- Jackshafts and outboard bearings can sometimes be eliminated.

Exclusive design features include: A Precisely Engineered Arched Top, Concave Sides, Flex-Weave Cover, super strength tensile construction.

Gates

Building the future on 50 years of progress

Gates Super HC V-Belt Drives

GOODYEAR

NEWS! ONLY V-BELTS BY GOODYEAR

to give you sets matched in length to pull together

What's more, Green Seal V-Belts give you—

True dimensional stability for the life of the belt—built in through the use of shrink- and stretch-resistant 3-T Process Cord or airplane-type steel cable.

Mildew-inhibited construction for protection in damp operating conditions.

Widest selection from the most complete V-belt line anywhere.

Ready availability from distributor stocks in every part of the country.

Technical assistance whenever it's needed from a qualified expert, the G.T.M.—Goodyear Technical Man.

For the best buy in V-belts call your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

Lots of good things come from GOOD

GREEN SEAL ARE CODED TO 1/32"...

perfectly for longer, more trouble-free service

LENGTH-CODING GREEN SEAL V-BELTS TO 1/32"—NOT JUST 1/10", LIKE MOST BELTS—takes this ultra-precision machine. Only Goodyear has this type equipment, which is set by means of fine tolerance steel templates to insure accuracy. Machine readings are in the actual code numbers used to eliminate errors.

Green Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

YEAR INDUSTRIAL PRODUCTS

Circle 253 on Page 19

Outstanding Performance...

CINCINNATI

CUSTOM GEARS AND GEAR BOXES are *outstanding performers* — the result of old-fashion craftsmanship applied to latest techniques and machines for gear making and inspection.

Ask for this brochure—CINCINNATI custom gears are made in all types to 72″ diameter cut teeth, 39″ shaved teeth, 25″ ground teeth.

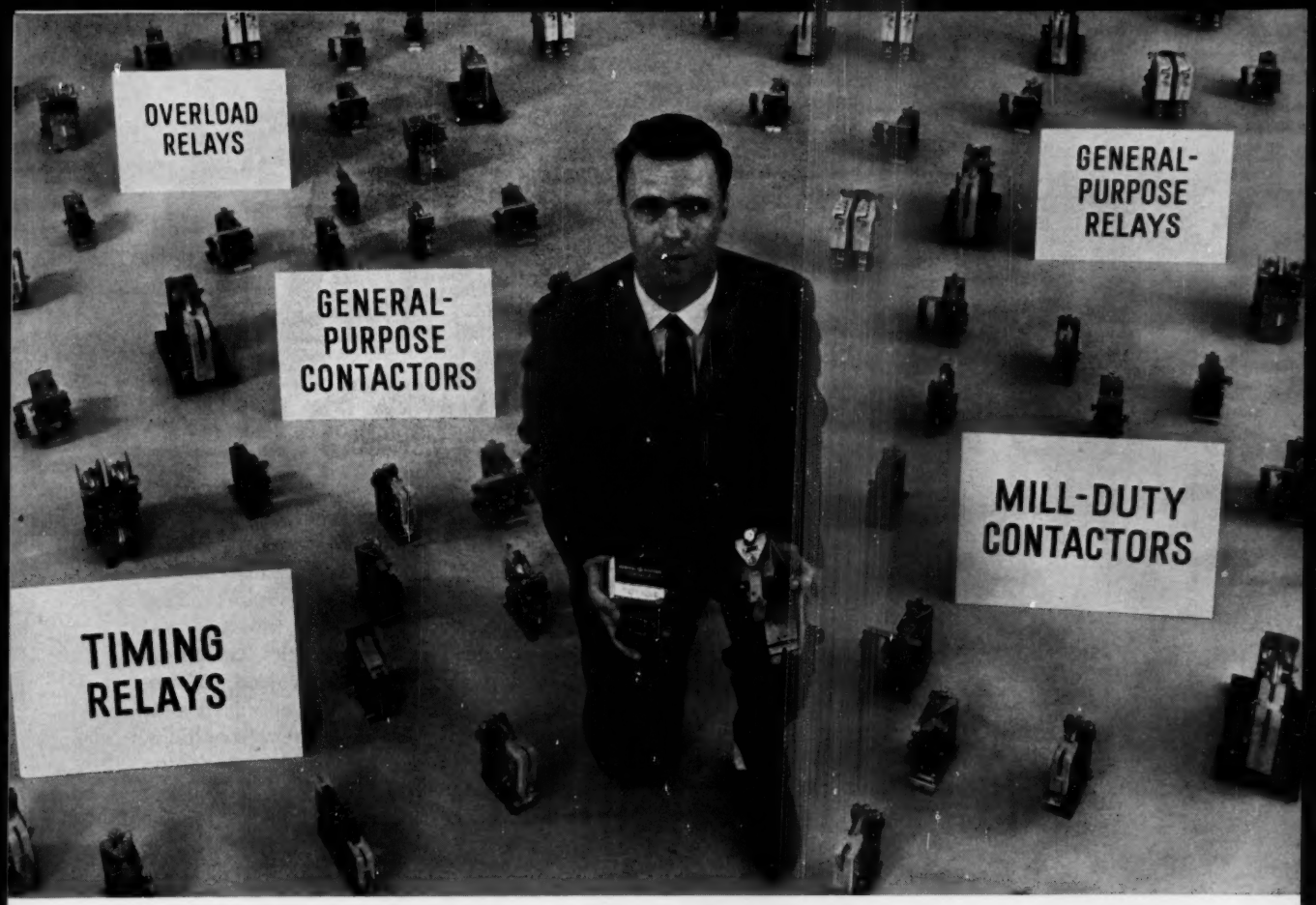
better still . . . Send us your prints for quotation

CINTI®

THE CINCINNATI GEAR CO.

Cincinnati 27, Ohio

Custom Gear Makers Since 1907 GEARS, good gears only



WHY STOCK DC CONTACTORS AND RELAYS?

. . . when you can assemble more than 100 devices from General Electric "building-block" components

There's no need to carry a large inventory of d-c contactors and relays . . . just to be sure you have the correct device when you want it!

"Building-block" design of General Electric contactors and relays permits you to assemble more than 100 different devices—right in your own plant—from a stock of as few as a dozen standard components.

G.E.'s "universal" contact block is the building unit for all types of contactors and relays. Choice of standard frame-and-coil assembly with proper combination of contact blocks and standard assembly kit permits the variation in devices to meet your specific application requirements.

Three complete contactor lines and six relay lines—for general-purpose, mill-duty, overload, and timing functions—can be assembled using this unique approach.

Rely on General Electric for all components—General Electric also has complete lines of plate rheostats and resistors. For additional information, contact your General Electric Sales Representative, or mail the coupon below. *Industry Control Department, Salem, Va.*

GENERAL ELECTRIC

Circle 255 on Page 19

Resistors—vitreous-enameled and wire- and ribbon-wound types from 5 to 1210 watts. Fixed, slide-wire, or tapped types available.

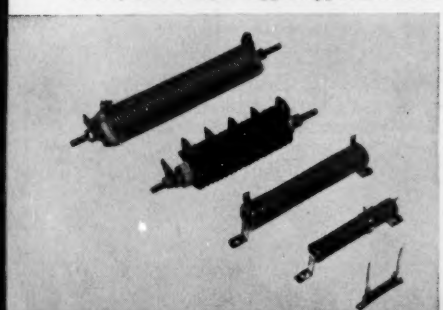
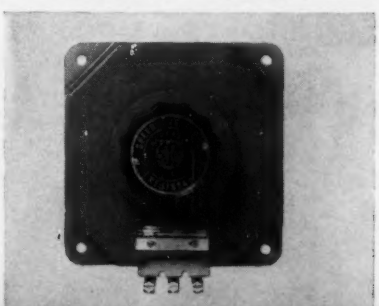


Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.



To: Section E784-31
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- ☐ GEA-6621—D-c contactors and relays
- ☐ GEA-6592—Resistors
- ☐ GEA-6474—Plate-type field rheostats

Name_____

Company_____

Address_____

City_____

State_____

GRAPHITAR®

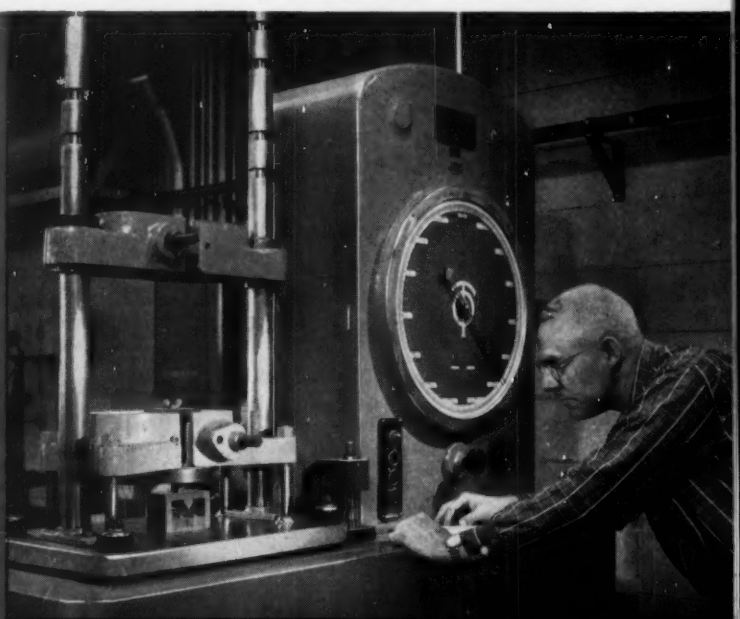
(CARBON-GRAPHITE)

FOR PERFORMANCE

Superior performance and unusually long service life, even in tough applications, is practically second nature to parts made of GRAPHITAR. That's because they combine GRAPHITAR's chemical stability, heat resistance, low coefficient of friction, adaptability to self-lubrication, mechanical strength, hardness and light weight. An everyday application of GRAPHITAR that illustrates well its versatility and remarkable performance can be found in the face-type valves employed in bulk station gasoline meters.

These valves incorporate GRAPHITAR seats. Here, GRAPHITAR's corrosion resistance, chemical inertness and resistance to expansion or contraction under rapid temperature changes, allow the valves to provide a leak-tight seal with excellent wear characteristics. These same characteristics are necessary for good performance wherever steam, gas and chemicals must be handled under the most adverse conditions. Perhaps your product can benefit from the top performance of GRAPHITAR, a unique and versatile engineering material.

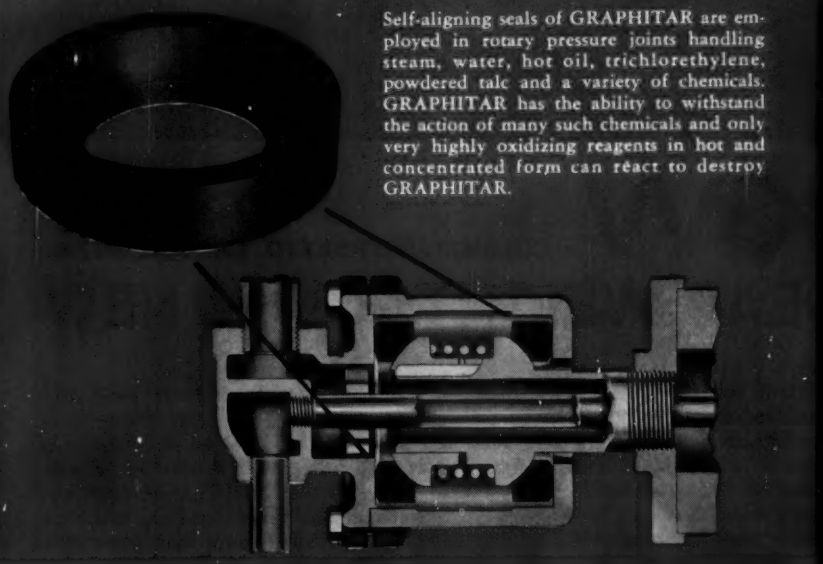
Comparative testing of various grades of GRAPHITAR self-aligning seals is accomplished on this equipment, which duplicates actual operating conditions. GRAPHITAR rotary pressure joint seals such as these often operate at 400 psi, at 650°F. and at rotary speeds of 600 ft/min.



Tests show that the compressive strength of GRAPHITAR grades varies from 4,500 to 45,000 psi. Correct part design can take advantage of this desirable characteristic to aid part performance.

GRAPHITAR's corrosion resistance and ability to withstand rapid temperature changes allow valve seats to provide efficient and dependable sealing in gasoline meters. Parts operate under 50 psi at 100 ft/min . . . and from 150 degrees F. to −70 degrees F.

Running directly in the gasoline reservoirs below ground level, a submersible, explosion proof pump depends on two GRAPHITAR bearings to keep its operation safe and smooth. GRAPHITAR is non-metallic, will not weld or score even when in contact with a dry metal shaft. Because GRAPHITAR operates with *any* liquid as a lubricant, it is an ideal bearing material wherever low viscosity liquids such as gasoline are encountered.



Self-aligning seals of GRAPHITAR are employed in rotary pressure joints handling steam, water, hot oil, trichlorethylene, powdered talc and a variety of chemicals. GRAPHITAR has the ability to withstand the action of many such chemicals and only very highly oxidizing reagents in hot and concentrated form can react to destroy GRAPHITAR.

GRAPHITAR is a material uniquely designed by its nature for solving tough problems and improving processing, and it can be further custom-engineered to meet your exact specifications. For complete information on GRAPHITAR . . . send for Engineering Bulletin #20.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 256 on Page 19

R-299-2

GLX-W COLUMBIUM-TREATED CARBON STEEL CUTS DEAD WEIGHT 10% IN NEW

VERSATILITY...
That's the Beauty of Steel

Bringing important new economies to rail shipment of automobiles, this new tri-level auto carrier holds twelve standard cars or mixed loads of 14 standards and compacts. Capacity is increased up to 75%. A unique system of hydraulically positioning the vehicles on three levels gives a clearance of only 16 feet 8 inches, permits use in areas formerly limited to bi-level unit operation because of clearance requirements. ◆ Key feature of the Multi-Car Carrier is the movable decks on which the cars ride. Made of GLX-W columbium-treated steel, the decks are raised and lowered by built-in hydraulic lifts, actuated by a portable power unit. Here light weight was essential, in order to reduce the operating power requirements. Yet great strength was necessary, too, to support the payload. Finally, design of the decks called for eight bends in each section. So formability was also a must. ◆ GLX-W met and exceeded all these requirements. It gives 50-100% greater strength than mild carbon steel, so builder Whitehead and Kales could get the required strength with less weight. Deck operating units need less power,

Great Lakes Steel is a Division of

Multi-Car Carrier built by Whitehead and Kales for Multi-Car Corporation, Detroit, Michigan

TRI-LEVEL AUTO CARRIER

and total weight is reduced approximately 5,000 pounds or 10%. Production is more economical, too, because the ductility and formability of GLX-W permits four of the bends in the deck to be performed in one press operation. ◆ The GLX-W series of high-strength steels consists of fine-grained, semi-killed mild carbon steels, treated with varying amounts of columbium. The high strength of GLX-W permits designers to reduce the amount of steel and effect considerable cost savings when replacing mild carbon steel. GLX-W steels have a low carbon content and are readily weldable and formable. GLX-W steels are available at four minimum yield strength levels: 45,000, 50,000, 55,000 and 60,000 p.s.i. and in sheets, plates and bars. For complete technical information, write Great Lakes Steel Corporation, Product Development, Dept. MD-9, P. O. Box 7310, Detroit 2, Michigan.

GLX W PATENT PENDING

A PRODUCT OF

GREAT LAKES STEEL

Detroit 2, Michigan

NATIONAL STEEL CORPORATION

Circle 257 on Page 19

The NEW Phillips
POZ-I-DRIV
a revolutionary new fastening development.

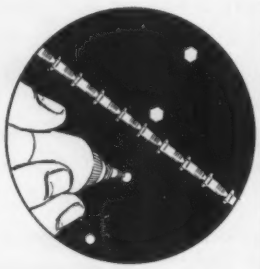
In 1933, American Screw Company gave industry the famous Phillips cross-recessed head, a fastener design that revolutionized assembly operations. And now, American presents the new POZ-I-DRIV fastener recess and driver . . . a development that offers significant reductions in assembly time and costs, increases fastening strength, improves product appearance and performance, and boosts profits.

The new POZ-I-DRIV recess is similar to the Phillips design, but provides greater driving area with reduced recess depth. This combination produces several significant advantages, including:

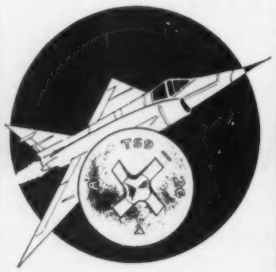
1. **GREATER TORQUING ABILITY** . . . making it possible to drive threaded fasteners tighter at continuous production speeds because of reduced operator fatigue.
2. **BETTER DRIVER-RECESS ENGAGEMENT** . . . practically eliminates cam-out, reduces bit wear, prolongs bit life.
3. **INCREASED DRIVING AREA** . . . with better driver stability permits shallower recess resulting in increased head strength.
4. **IMPROVED AXIAL ALIGNMENT** . . . and positive bit engagement permit 90° offset driving.
5. **COMPLETE COMPATIBILITY** . . . with present Phillips bits for field service.

AMERICAN SCREW COMPANY
Leader in Fastener Development

Since 1838, American has been making important contributions to industrial progress by the continued development of new and better threaded fasteners. Here, for example, are 3 recent developments by American Screw Company:



SCREWSTICK . . . consists of machine and fluted thread-cutting screws in "stick" form. Used with automatic-feeding driving tools, they can be applied as fast as the operator can position the assembly. Available in steel, brass, aluminum, nickel silver and stainless steel alloys.



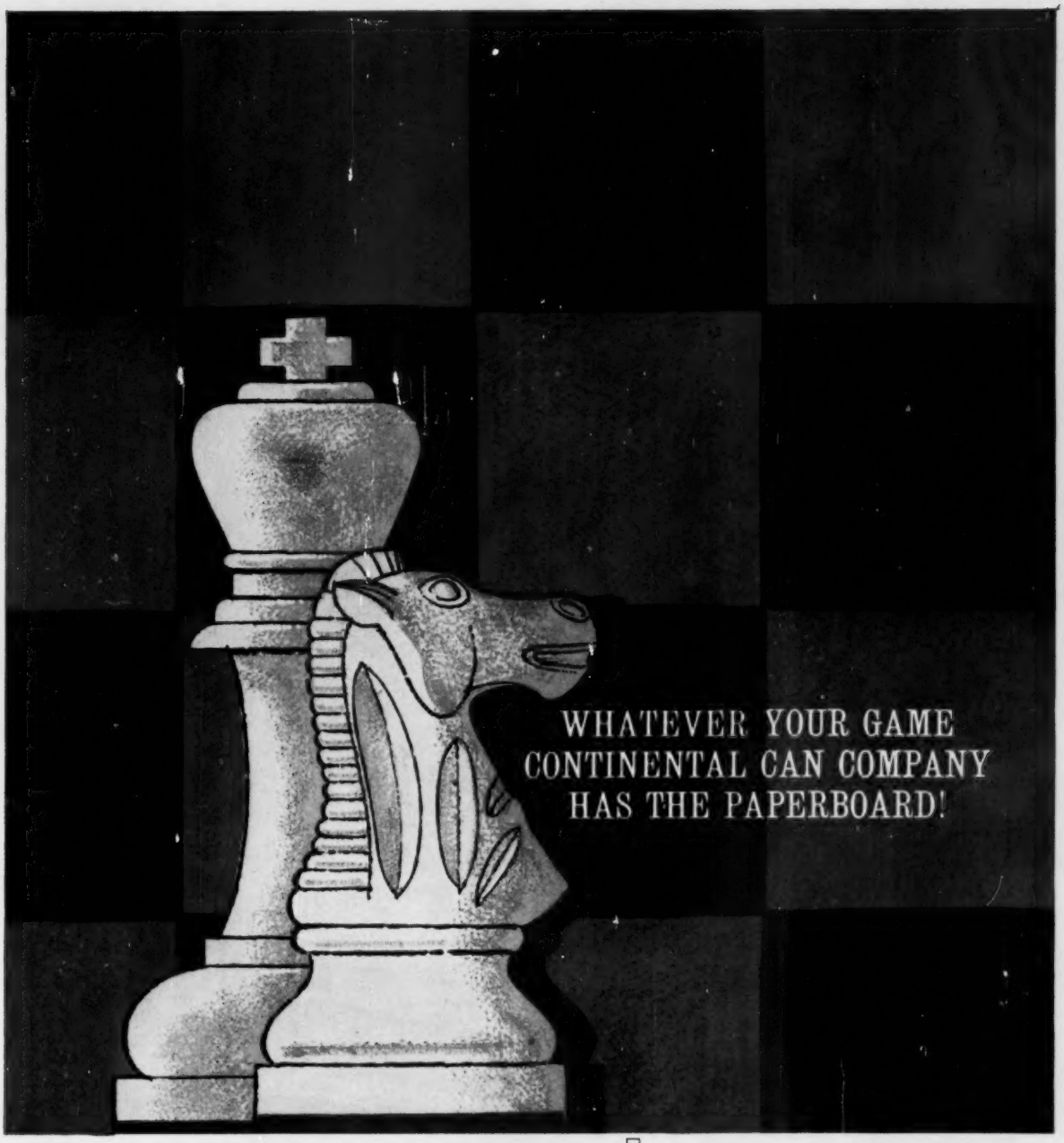
TORQ-SET . . . designed for the expanding needs of supersonic aircraft, missiles and electronic components, where maximum wrenchability and reliability are of prime importance. Recess design eliminates burring that would interfere with laminar flow.

TRI-WING . . . a tamper-proof fastener, which is virtually impossible to remove without mating tool. Designed for maximum security against tampering or pilferage. With high torquing characteristics for applications requiring extreme strength or vibration resistance.

1838

AMERICAN SCREW COMPANY
WILLIMANTIC, CONNECTICUT
A Division of **NOMA LITES, INC.**

Circle 258 on Page 19



Whether you make gameboards, book covers, record albums, or any of the hundreds of other items fashioned of versatile paperboard, you'll find you are serviced best by Continental Can Company. And, Continental Can Company makes the widest variety of paperboard —for the widest variety of uses—available anywhere. Paperboard probably belongs in whatever you design, make, fashion or fabricate. And for every paperboard need contact Continental Can Company. ...You can't buy better.

To learn more about the use of paperboard in all phases of industry, send coupon to: Paperboard and Kraft Paper Division, Continental Can Company, 530 Fifth Ave., N. Y. 36, N. Y.

by CONTINENTAL CAN

PAPERBOARD...the best material for so many uses!

SEND COUPON TODAY!

I would like further information on the use of paperboard. No obligation, of course.

Name_____

Organization_____

Address_____

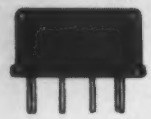
_____

Tel._____

PAPERBOARD & KRAFT PAPER DIVISION / CONTINENTAL CAN COMPANY, 530 FIFTH AVENUE, NEW YORK 36, N. Y.

a New and superior latching P&B relay...

LIES FLAT FOR GREATER PACKAGE DENSITY, HIGHER PERFORMANCE



This DPDT, permanent magnet, latching relay is superior on these counts: (1) shorter height for maximum compactness between stacked circuit boards; (2) greater sensitivity (80 milliwatts); (3) better vibration resistance (30 g to 2000 cps); (4) better shock resistance (100 g).

Designated the FL Series, this relay meets all applicable sections of MIL-R-5757D, MIL-R-6106C and ABMA #PD-R-187.

FL SERIES SPECIFICATIONS

Contact Arrangement: DPDT

Shock: 100 g for 11 milliseconds with no contact openings.

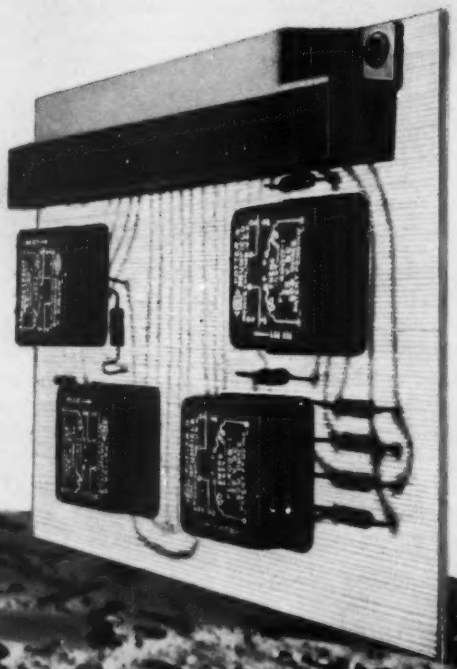
Vibration: .195" max. excursions, 10 to 55 cps. 30 g from 55 to 2000 cps. No contact openings.

Linear Acceleration: 400 g minimum with no contact openings.

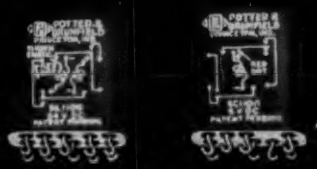
Pull-In: 150 milliwatts, approx. (standard) at 25°C. coil temperature. 80 milliwatts, approx. (sensitive) at 25°C. coil temperature

Operate Time: 3 milliseconds max. at nominal voltage at 25°C. coil temperature

Dimensions: .485" high, 1.100" long, .925" wide.

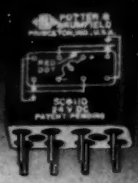


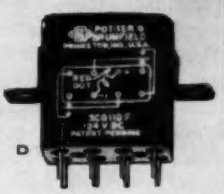
Printed circuit board using 4 FL relays was designed by the Martin Company, Orlando, as part of ground support equipment for a major missile project.

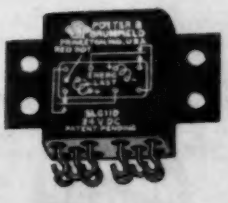


HOW P&B microminiature RELAYS can be tailored to your requirements

This large family of dual coil, permanent magnet relays can be supplied with built-in diodes, special terminals and mounting brackets.







A Non-latching or latching relays can be supplied in conventional crystal cases with or without shoulder brackets, studs or mounting plates. Straight pin, hook-end or 3″ flexible terminals are available.

B Potting 3″ terminals with epoxy resin at the relay's header keeps glass beads from cracking through mishandling during installation . . . adds only .25″ max. to height of case. Your production is speeded, reliability is increased.

C A diode becomes an integral part of the relay circuit in SC or SL relays. It is incorporated in the relay case and is used to minimize arcing in special applications. Four diodes can be used as a full-wave bridge rectifier for 400 cycles.

D Terminals spaced on .200″ grids are available on all P&B microminiature relays. These carry a "G" suffix (SCG and SLG) and are only slightly larger in size, measuring .890″ high, .800″ wide, .400″ deep, max.

SC/SL SERIES SPECIFICATIONS

GENERAL:

Shock: 100g for 11 millisec.

Vibration: 30g from 55 to 2000 cps .198″ max. excursions from 10 to 55 cps.

Ambient Temperature Range: −65°C. to +125°C.

Contact Arrangement: DPDT.

Contact Load: 2 amps at 30 vdc, 1 amp at 115 vac, 60 cycle.

Sensitivity: SL—220 milliwatts at 25°C.
SC—250 milliwatts at 25°C.

COIL VOLTAGES to 36 vdc.

TERMINALS:

Straight Pin: SC11D (8 pins)
SL11D (10 pins)

Hook Ends: SC11DA & SL11DA
SC11DB & SL11DB
SC11DC & SL11DC
SC11DD & SL11DD

MOUNTINGS:

Plug In: SC11D & SL11D

Shoulder Bracket: SC11DA & SL11DA

Flat Plate: SC11DB & SL11DB

Back Mount: 2 4-40 Studs: SC11DC & SL11DC

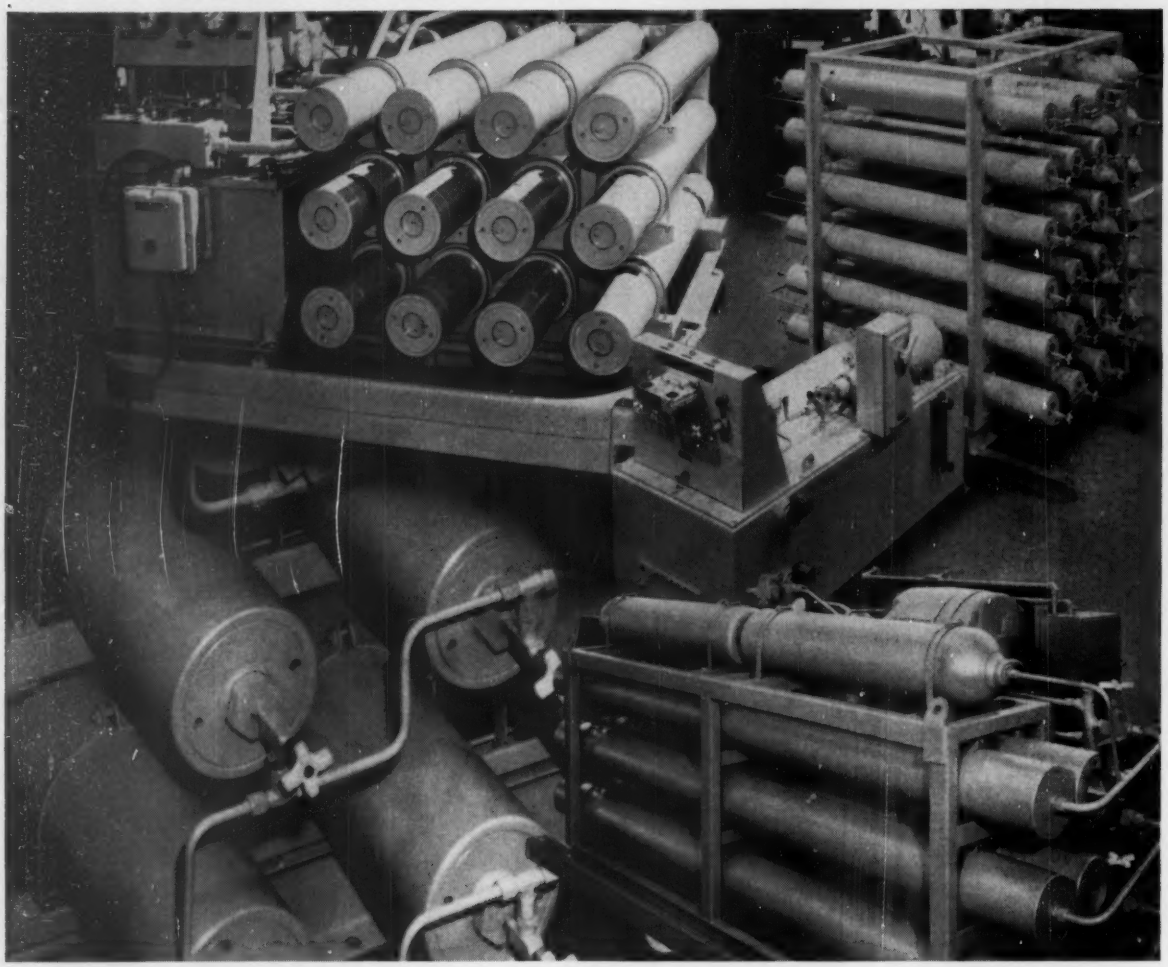
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONICS PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

Now... more new accumulators from AMERICAN BOSCH!



AMERICAN BOSCH ACCUMULATORS
are tailored to fit the job!

Now—American Bosch offers the most complete line of piston-type accumulators on the market! Sizes range from less than a quarter pint to twenty gallons. Models are available for a variety of pressures in both steel and aluminum—in many diameters, lengths and capacities to handle any job.

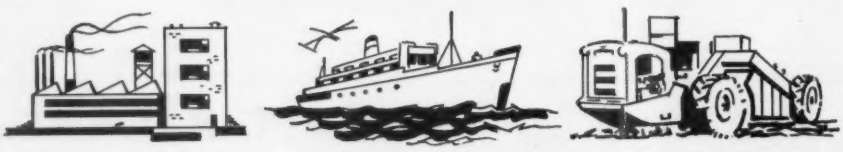
American Bosch accumulators are designed and manufactured to meet the most rigid requirements. They combine many features to provide the utmost in performance and reliability.

When you specify accumulators for hydraulic systems—call for AMERICAN BOSCH ACCUMULATORS! Details are included in folder AC 110-02-2. Write for a copy and the name of your nearest distributor.

AMERICAN BOSCH ARMA CORPORATION

Commercial Sales Division • Springfield, Massachusetts

MOVE AHEAD with AB



ACCUMULATORS FOR INDUSTRIAL, MARINE AND MOBILE APPLICATIONS

first in silicones

Dow Corning

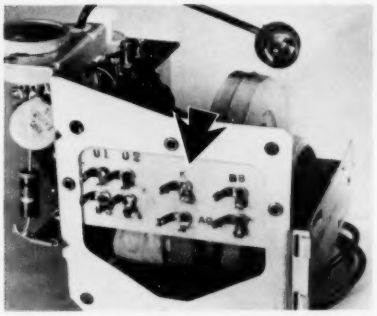
SILICONE NEWS

for design and development engineers • No. 85

FOR BETTER TV

Production of flyback transformers for RCA "Living Color" TV sets is expedited by the use of terminal boards made from silicone-glass laminates produced by Taylor Fibre Company of Norristown, Pa.

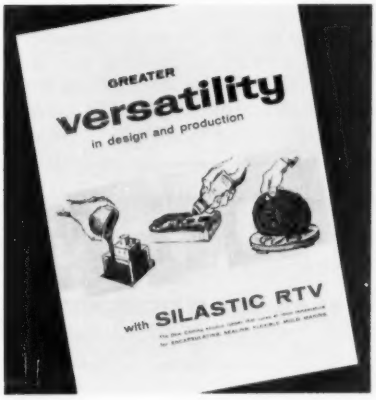
Bonded with a Dow Corning silicone resin, these laminates easily withstand 250 C continuously . . . much higher temperatures for shorter times. Soldering heat doesn't loosen terminals or slow production. Good electric and physical properties, ease of fabrication, and resistance to creep-under pressure of terminal fasteners add up to a top quality high voltage laminate that lends itself to mass production. *No. 242*



NEW DESIGN TOOL

A rubbery liquid that flows where you want it; a rubbery paste that stays where you put it; a rubbery solid that insulates and cushions, bonds or releases — this is Silastic® RTV.

Silastic RTV is a down-to-earth working tool for design and *(Cont. Pg. 2)*



More Horses, Less Fuel

Fuel consumption is an important element when computing operating costs for trucks, buses, off-the-road vehicles and earth-moving machines. That's why the silicone-filled Thermo-Modulated Fan Drive made by Schwitzer Corporation, Indianapolis, delivers impressive savings. Here's how:

Conventional fan-drives waste fuel because they overwork—cool more than necessary under a majority of operating conditions. Engines can lose up to 10% of total power output just driving the fan when cooling is not required. The Schwitzer fan drive eliminates this waste by relating fan speed to engine coolant temperature.

Because engine power absorbed by a fan is a cubic function of its speed, even slight reductions in fan RPM result in significant fuel savings. Schwitzer claims a 5 to 10% fuel savings and, in addition, attributes reduced maintenance, longer engine life, and a substantial reduction in noise to the use of their drive on commercial vehicles.

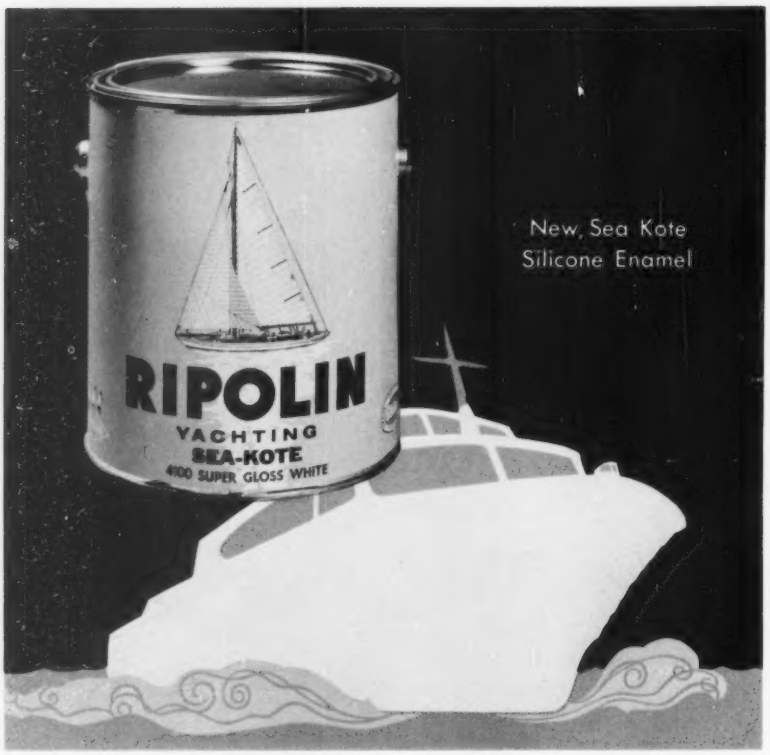
Operation of the fan drive is based on simple principles: Torque is transmitted from the input shaft to the fan by the shearing of a fluid film between input and output plates in a silicone fluid filled housing. The control element, which reacts to engine temperatures, varies the thickness of the fluid film between the plates to change fan speed. Naturally, the properties and stability of the fluid medium determine in large measure the accuracy, responsiveness and reliability of the device.

Schwitzer engineers chose a Dow Corning silicone fluid for the viscous drive medium because 1) it is uniquely resistant to breakdown under shear; 2) it retains near-constant viscosity (uniform driving force) over wide temperature spans; 3) it resists oxidation, won't evaporate, thicken or thin out after extensive use.

For more information on how the outstanding properties of silicone fluids can aid you in damping, torque conversion and hydraulic applications, circle . . *No. 241*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



New Enamel Keeps Gloss Longer

You can make your product's brand-spanking-new factory paint job last almost indefinitely by specifying a finish based on Dow Corning silicone resins. A good example of the "extras" you can expect with silicones is found in the new SEA-KOTE marine enamel produced by the Glidden Company, Cleveland, Ohio.

Glidden is confident its new silicone base SEA-KOTE Super Gloss enamel will retain 90% of its original rich gloss after a full year's service above or below waterline in fresh water, or above waterline in salt water. For boat owners, this means no more mid-season refinishing, new convenience and increased satisfaction.

Glidden has tested the enamel in actual use for four years under the worst possible conditions. In addition to repeated exposure to sun, wind, rain and moisture, SEA-KOTE has withstood the ravages of sulfurous gases, sewage infested harbors, oil slicks, exhaust fumes, salt air and exposure to prolonged sunlight. Silicones help keep the paint's slick surface dirt-free . . . toughen the film so it will retain its high gloss, mirror smooth finish almost indefinitely.

If your product could use a coat of beauty that lasts like a coat of armor, it will pay you to investigate the ever-increasing number of silicone-based baking enamels and air dry finishes offered by leading paint formulators. For more information and list of sources, circle . . . . *No. 244*

new literature on silicones

Electronic Engineer's Guide describes all the silicone products that contribute to realiability, miniaturization and environmental protection of electronic components. From satellites to seismographic instruments, this 16-page electronics engineer's guide describes the various forms of silicones that help improve design. *No. 245*

Space Age Silicones are described in thirty typical application stories. Utilization of silicone compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants are illustrated for your consideration. This valuable brochure offers solutions to many problems encountered in designing space age aircraft and ground support equipment. *No. 246*

Four Simple Steps to making silicone rubber molds for short run castings are described in an article reprinted from PRODUCT ENGINEERING. Silastic RTV, the fluid silicone rubber that cures at room temperature, makes it possible to produce flexible molds and patterns for casting metal or plastic parts, even with most intricate detail, cheaply and quickly. An ideal means of making prototype parts. *No. 247*

Does silicone rubber resist solvents, chemicals, oils, fuels, and other fluid media? Sometimes it does and sometimes it doesn't. New 20 page bulletin lists the effects of over 250 fluids from coffee to jet fuel on Silastic silicone rubber after immersion for varying times and temperatures. For free copy, circle . . . . . *No. 248*

SILASTIC RTV *(Continued)*

production engineers. When poured or squeezed into place, this silicone rubber cures at room temperature to a tough, resilient solid that has the resilience of rubber *plus* the indestructibility of its silicone ancestors. Silastic RTV's physical and electrical properties are unaffected by heat, cold, moisture, ozone and corona.

A just-released eight-page brochure illustrates and gives details about Silastic RTV and its applications. Included also is a Selector Guide which describes the properties of each of the various RTV systems. To obtain your copy, circle . . *No. 243*

Dow Corning Corporation, Dept. 6928, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248

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TITLE_____

COMPANY_____

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CITY_____ ZONE___ STATE_____

SILICONE NEWS is published for design and development engineers by

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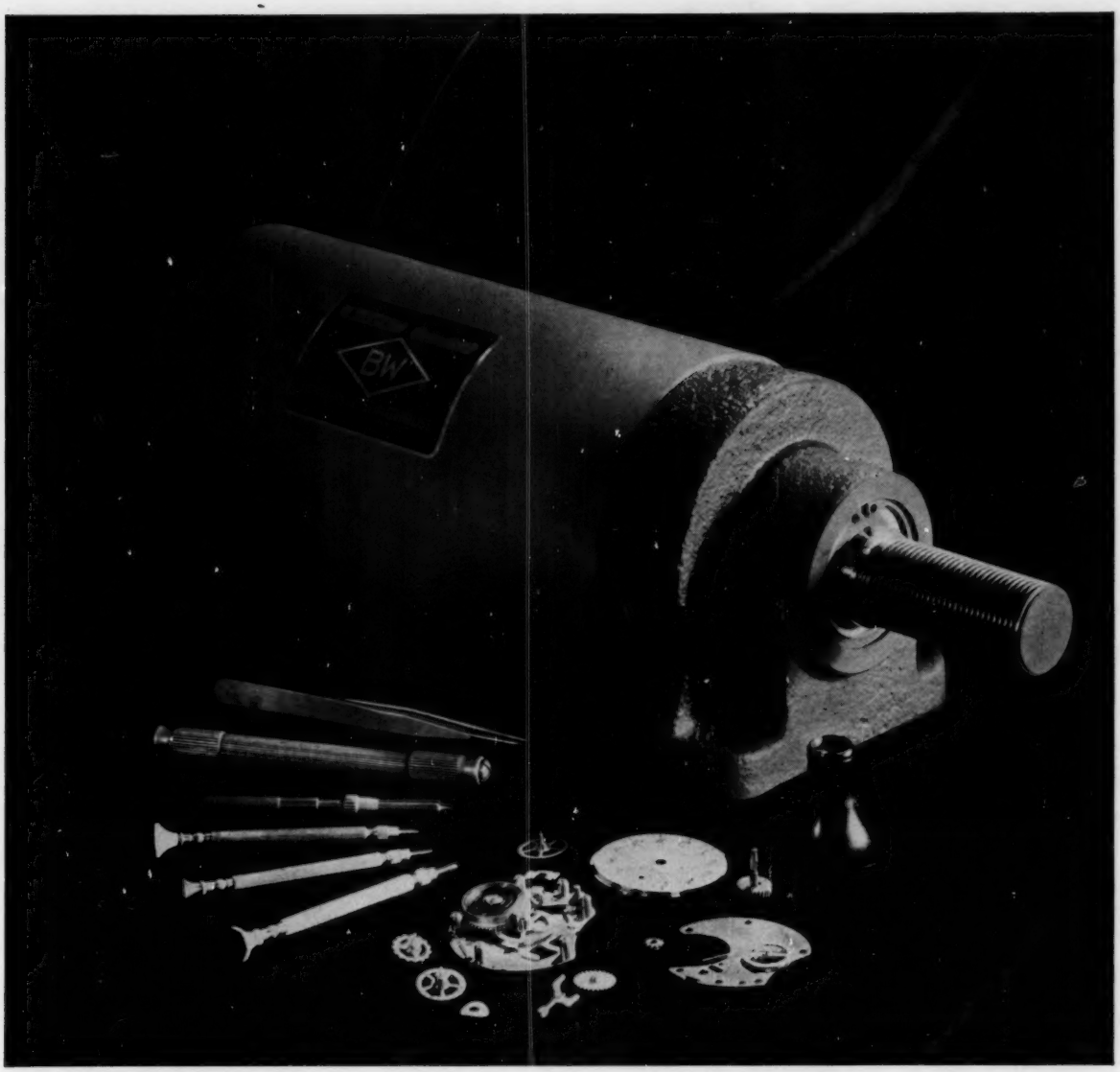
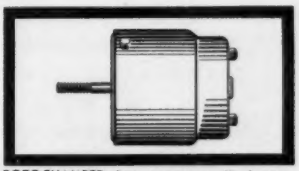
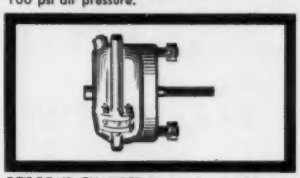


Quality materials and craftsmanship... Bendix-Westinghouse Power Cylinders

You can count on Bendix-Westinghouse for the best in design, materials, and manufacture. Our power cylinder capabilities result from actual experience in every imaginable application—medium, heavy-duty, standard, and special. Our comprehensive inventory of machined parts for standard units, combined with our manufacturing flexibility, means fast delivery to meet your needs. In addition to the broad range of standard models, we can "customize" to your requirements with specialized sizes and mounts. Write today for complete information on the quality advantages you enjoy with Bendix-Westinghouse engineering and manufacturing.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

Bendix-Westinghouse BW®

INDUSTRIAL PRODUCTS

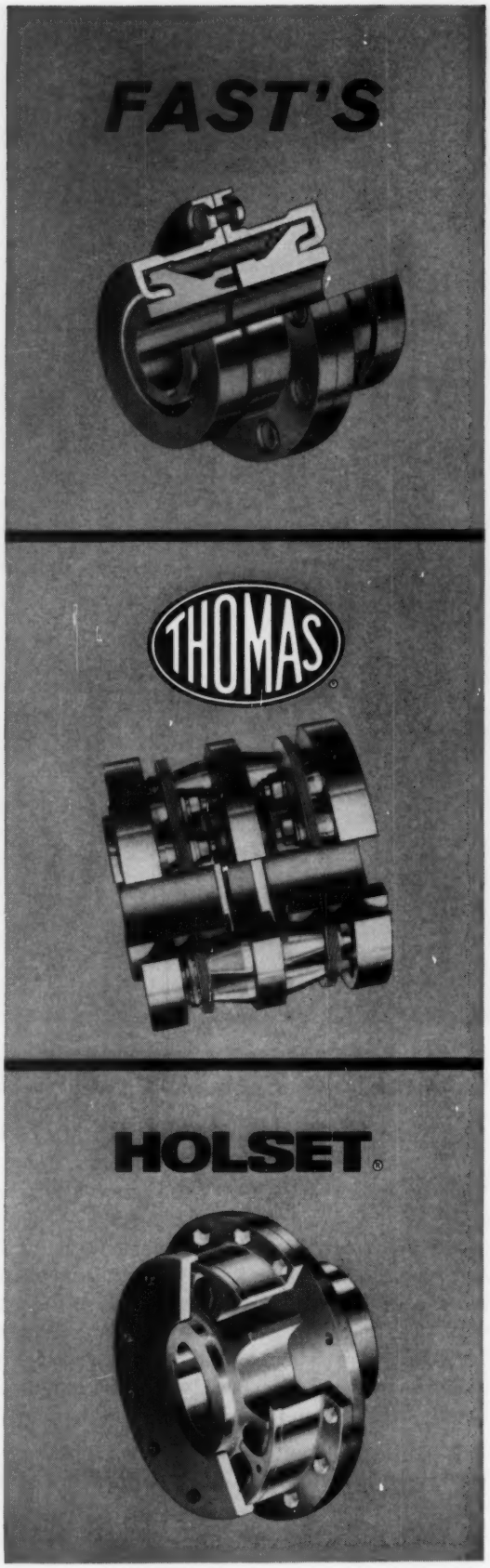
Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

Circle 262 on Page 19

Three great names in couplings

NOW CARRY THIS CORPORATE SYMBOL

KOPPERS®



With the acquisition of the Thomas Flexible Disc Coupling line, Koppers now provides engineering solutions to a wide range of industrial coupling problems. Need a lubricated gear-type coupling for transmitting high loads? Koppers world-famous Fast's coupling line does the job on shafts up to 32 inches. Need a maintenance-free flexible-disc coupling with no backlash? The highly engineered Thomas line holds the answer—with miniature couplings as small as 1/12th of an ounce. Need a coupling to absorb impact or vibration? The Holset line of resilient, non-lubricated couplings protects equipment in most diesel, compressor and shock load applications.

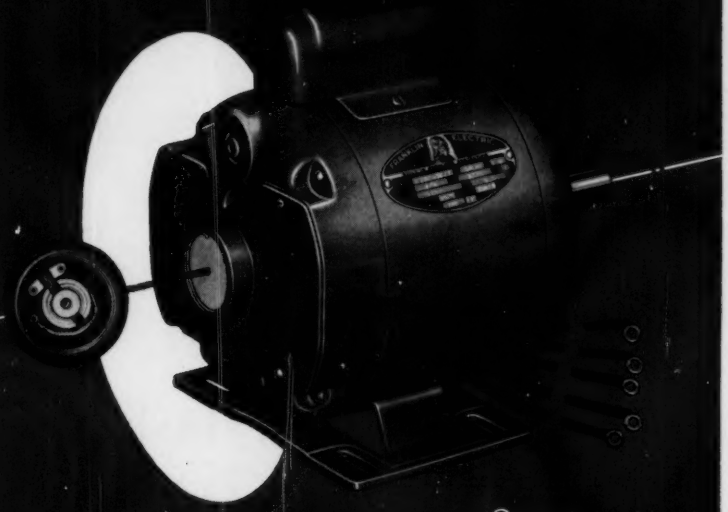
Because each of these coupling lines has its particular application in industry . . . and because each is a recognized name in the power transmission field . . . you can continue to buy them by brand—just as you have in the past. Of considerable importance are the experienced, extensive engineering and manufacturing services of the entire Koppers organization that are available to help you with your power transmission problems . . . in any size, in any quantity, for any use.

KOPPERS COMPANY, INC.
COUPLING DEPARTMENT
Baltimore, Md. • Warren, Pa.
Engineered Products Sold with Service

Franklineered

INSTANT-REVERSING MOTORS

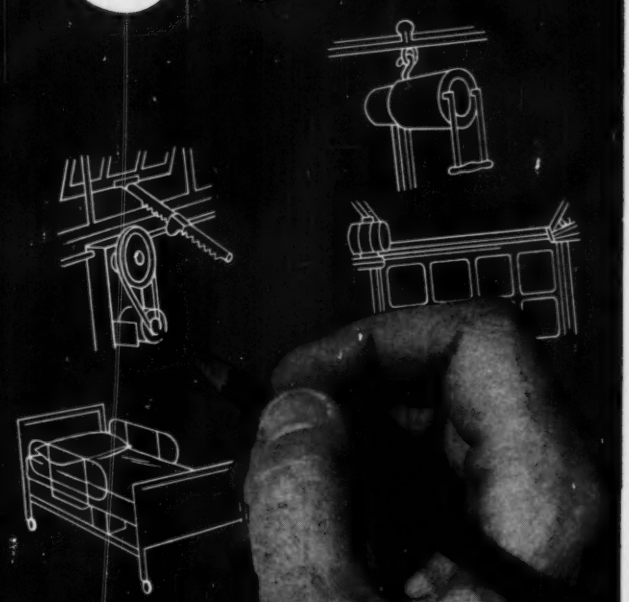
Applicable to products requiring full-power, instant reversing with economies attendant to single-phase motors. 1/6 H.P. through 1 H.P., 1725 rpm, 115 or 230 V.



INST-O-VERSE® motors by Franklin utilize full torque **instantly** because there is no dependency on a relay or the delaying mechanical contact of the centrifugal switch. The INST-O-VERSE® device, preset by shaft rotation, reverses motor on automatic or manual signal.

INST-O-VERSE®

Encourages fresh thinking for new product design or to improved product performance-dependability. Write for facts brochure.



FRANKLIN ELECTRIC

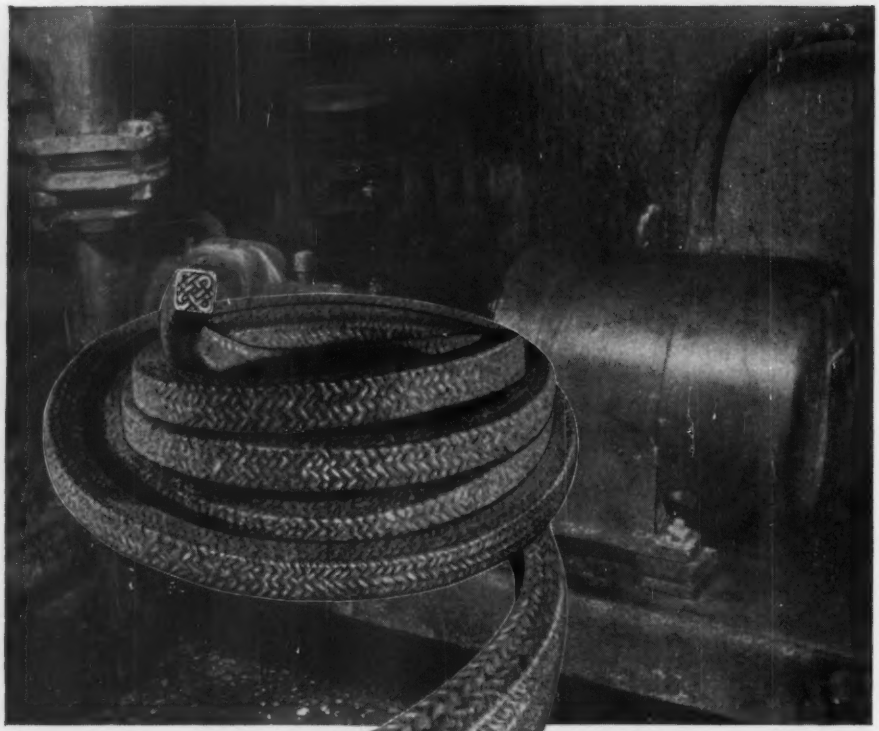
Franklin Electric Co., Inc.

BLUFFTON, INDIANA

DEPENDABLE MOTORS BACKED BY NATIONWIDE SERVICE

Circle 264 on Page 19

Apply Garlock 5875 Teflon-impregnated LATTICE BRAID Packings to centrifugal and rotary pump shafts, valve stems and expansion joints, and reciprocating rods, rams, and plungers . . . a premium packing at regular packing prices.**



**Patent applied for

ENGINEERED TEFLON* PRODUCTS

Exclusive Garlock manufacturing technique creates unique properties in Teflon-impregnated LATTICE BRAID Packings. The use of pre-sintered Teflon powder gives new, low cost Garlock 5875 LATTICE BRAID† Packing greater stability under temperature changes and outstanding resistance to glazing. The pre-sintered Teflon powder on the white asbestos yarn does not absorb water; hence, there is no "wicking" action, and minimum axial swell. The ground particles of Teflon form millions of bearing points on the packing surface . . . effectively reduce friction and wear . . . once installed, retightening or adjustments are rarely, if ever, necessary. Garlock 5875 LATTICE BRAID Packing contains over 30% Teflon by actual weight—affords excellent resistance to moderately destructive and corrosive acids and caustics from −90°F to +500°F.

Costs no more than regular packing. Garlock 5875 LATTICE BRAID Packing sells for almost 40% less than other Teflon packings in use today. At this price, you can enjoy all the new features of 5875 plus the advantages of LATTICE BRAID construction: completely integrated structure for greater strength, longer life, more flexibility and lower maintenance cost. No single outer braid or cover to wear through. Garlock 5875 LATTICE BRAID holds together without disintegrating, wears far beyond ordinary packings.

Enjoy fast delivery from warehouse stock. Garlock 5875 Packing is immediately available in sizes from ¼" through 1" in either spool or reel form to meet your specific needs. Call your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-185, Garlock Inc., Palmyra, New York.

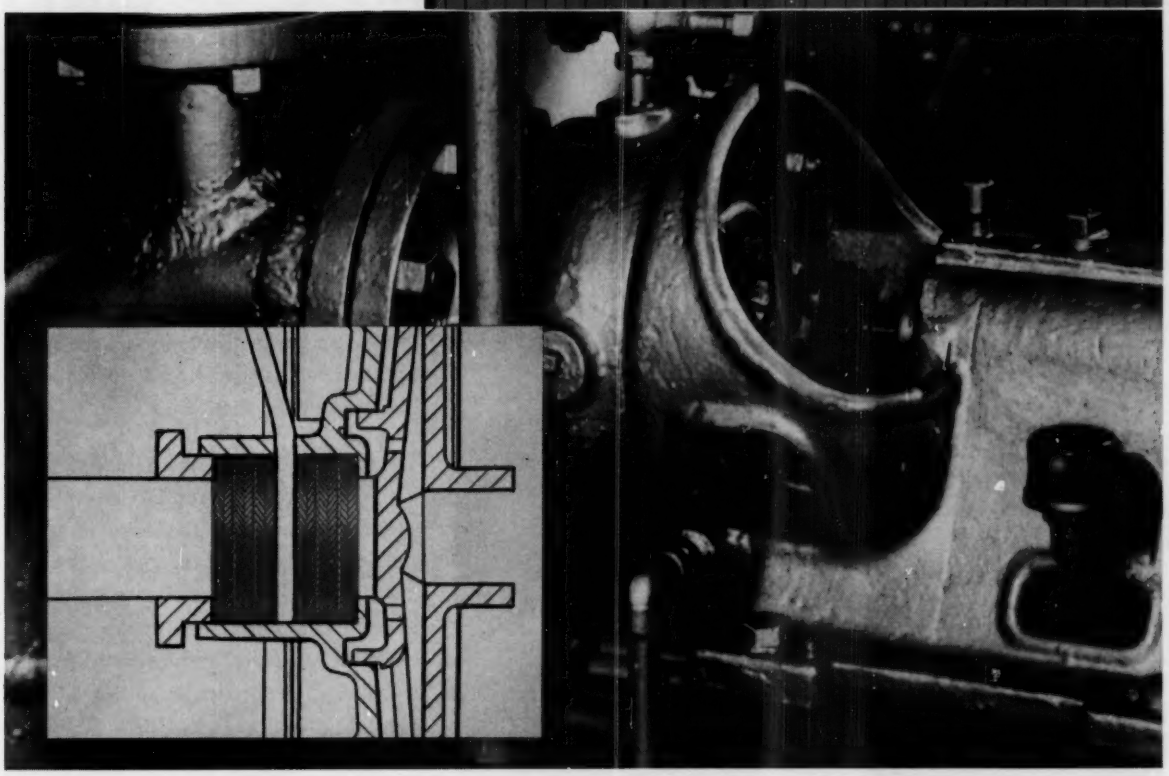
Canadian Div.: Garlock of Canada Ltd. **Plastics Div.**: United States Gasket Company. **Order from the complete line** of quality Garlock products . . . Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts.

*DuPont Trademark for TFE Fluorocarbon Resin †Registered Trademark

GARLOCK

DU PONT

TEFLON®



Pump packings of asbestos and TEFLON® TFE eliminated retightening... replacement... shaft damage

CAN YOU AFFORD NOT TO USE TEFLON?

Packings made with TEFLON are your logical and most economical choice whenever severe environmental conditions are encountered, AND in all cases when you want—

... greatly reduced packing maintenance
... reduction of replacement costs
... reduced cylinder and shaft wear
... greater standardization with reduced packing inventories
... the competitive advantage of quality and dependability

If any of these considerations are important to your design, the choice of any other kind of packing material might well be wasteful.

DU PONT
REG. U. S. PAT. OFF.

Asbestos impregnated with a Du Pont TEFLON TFE-fluorocarbon resin is the packing material used in the condensate pump shown above. This centrifugal pump operates at 3500 rpm, returns condensate—water at 110°F. to 175°F.—to a de-aerating tower. It operates with a –9-ft. suction to a 45 psi head. Before packings made with TEFLON were installed, packings required retightening five times per year, replacement once a year. The new packings have been in service over five years ... have needed no maintenance ... and have eliminated the danger of scoring and abrasion resulting from squeeze-out of conventional additives.

Under more severe service conditions, TEFLON resins are often the only answer. These materials are inert to virtually all chemicals and solvents, at temperatures from –450°F. to 500°F.

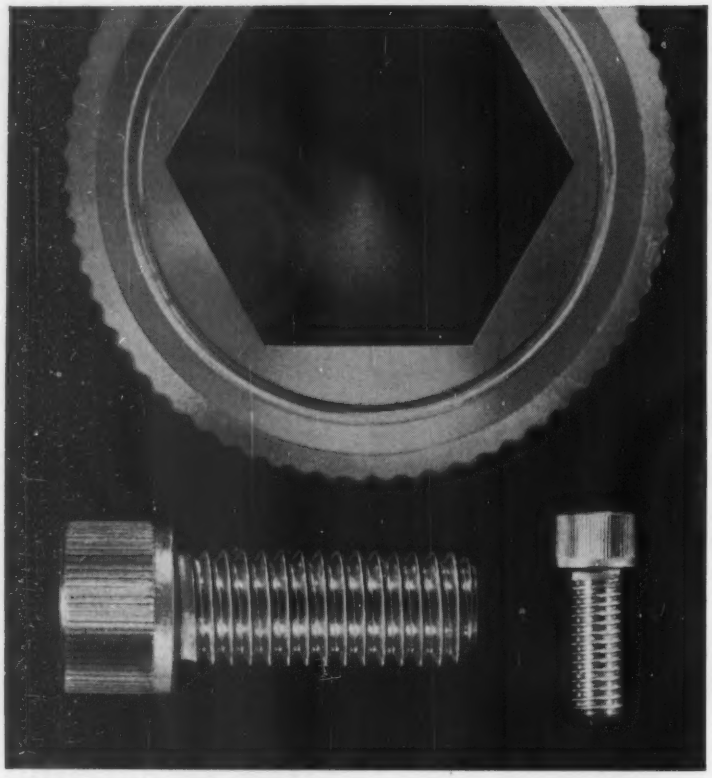
Consult your supplier about the many constructions available in packings made with TEFLON. Write for the new booklets: "Packings for Valves and Pumps" and "Designing with TEFLON". Address E. I. du Pont de Nemours & Co. (Inc.), Dept MD-817, Room 2507T, Nemours Building, Wilmington 98, Delaware. **In Canada:** Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON®
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*

New UNBRAKO stainless socket screws offer 125,000 psi minimum tensile—certified!



Groove around socket identifies UNBRAKO KS 812 stainless tension fasteners, latest in new SPS high-performance K Series. Affidavit certifying 125,000 psi minimum tensile accompanies every lot.

TYPICAL MECHANICAL PROPERTIES
UNBRAKO KS 812 Stainless Socket Head Cap Screws

Test Temp.	−60°F	Room	800°F
Ultimate tensile strength, psi	147,000	131,870	101,400
Yield strength, psi	94,000	80,700	70,900
Shear strength, psi		85,000	
Fatigue endurance, psi		40,000	
Stress relaxation Initial stress 65,000 psi Residual stress after 50 hr			55,000
Magnetic permeability		below 1.05	

Besides high tensile strength, KS 812 offers good shear and endurance properties, adding to overall reliability of your stainless assemblies. New fastener meets or exceeds AMS 7472, FF-S-86.

If you are looking for more fastening strength in your stainless designs (without going to specials) . . . or for ways to reduce size or number of fasteners . . . the new UNBRAKO KS 812 provides an answer. Here at last is a stainless steel socket head cap screw offering a guaranteed tensile strength of 125,000 psi minimum. Yet this precision-forged, burr-free fastener is a standard, available in quantity off the shelf.

To make a corrosion-resistant cap screw that can be certified for 125,000 psi tensile, SPS uses a high-grade austenitic stainless, hardening it through cold working. Heads and sockets are forged; threads are rolled to preserve integrity of grain structure and enhance overall mechanical properties. Also the KS 812 has both the UNBRAKO pHd* head, which gives greater holding power, and the SPS Hi-Life thread root form, which increases fatigue resistance.

UNBRAKO KS 812 socket screws offer high corrosion resistance over a wide range of applications, as well as low magnetic permeability (under 1.2). Serviceable from −300° to 800°F, they come in sizes #8 through ⅜ in., fine or coarse thread. Ask your UNBRAKO distributor for more details or write Standard Pressed Steel Co. for new Bulletin 2734. INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PENNSYLVANIA.

*proper Head design (1960 series—standard on all UNBRAKO socket head cap screws, as is Hi-Life thread)

SPS

where reliability replaces probability

ALLEN-BRADLEY SELECTS Flexonics BERYLLIUM COPPER BELLOWS

for longer life . . . higher pressures

Beryllium copper was selected as the metal for the Flexonics bellows in the new Allen-Bradley Bulletin 836 Style T Oiltight Pressure Control. Advantages gained include . . . longer cycle life . . . ability to withstand higher pressure . . . and negligible hysteresis for up to 80% of compression stroke. Specifications of the Allen-Bradley Style T Pressure Control are: Adjustable range 0 to 35 psi . . . adjustable differential 1½ to 7 . . . maximum allowable pressures 60 psi (line), 80 psi (occasional surge).

OTHER FLEXONICS BELLOWS

FLEXONICS CAN HELP YOU. If you are confronted with a problem involving absorbing, compensating, transmitting, or converting energy or force, your answer may well be a bellows. A good source of counsel is the Flexonics Application Engineering Staff. These men are experienced in all areas of bellows application from the simple sensing device of the domestic range to highly intricate and delicate fluid metering controls for missile engines. Flexonics bellows can be furnished in a broad range of metals. You are invited to submit your problem for analysis—without obligation.

B-540

Flexonics

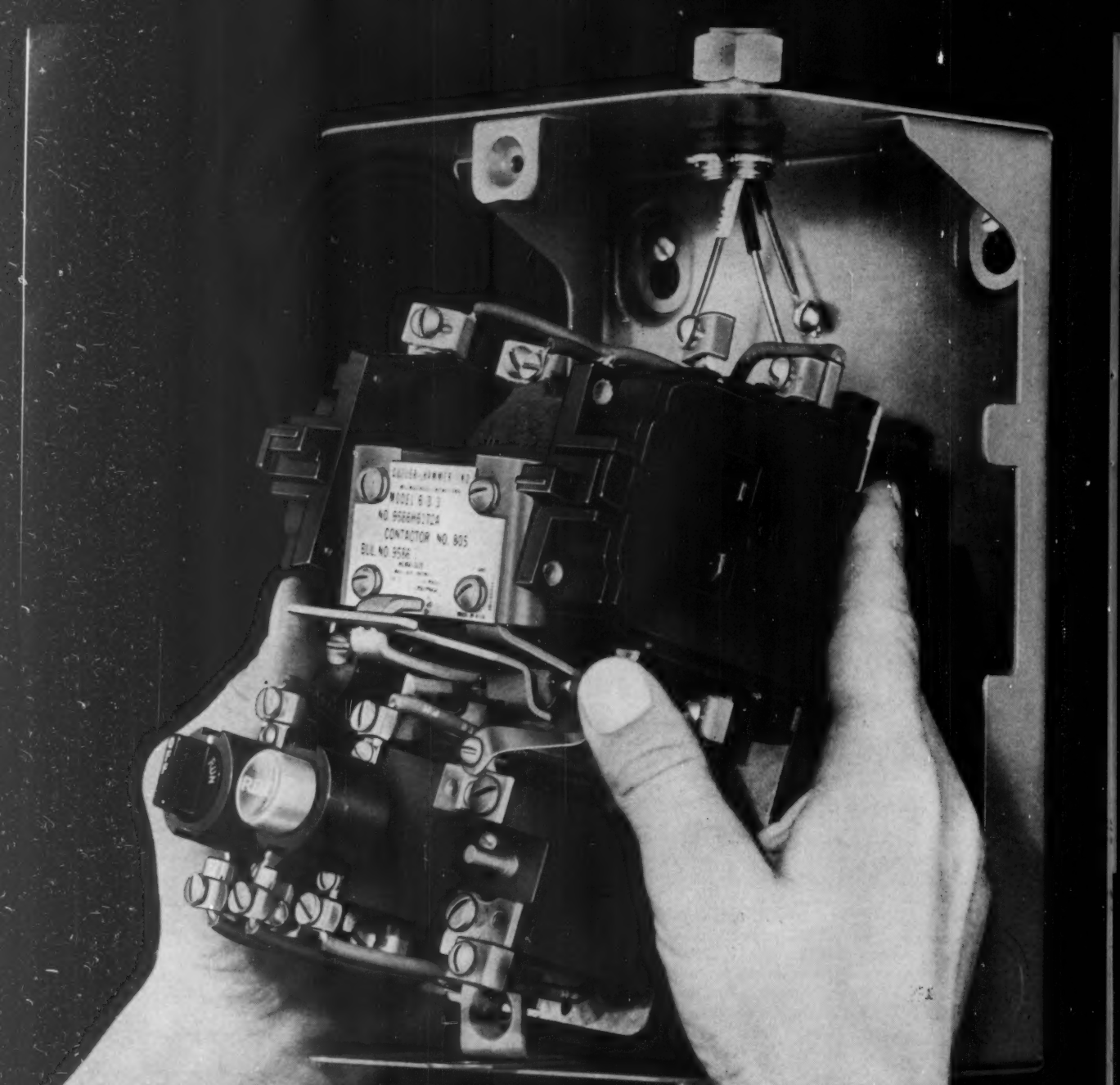
DIVISION OF CALUMET & HECLA, INC.
350 East Devon Avenue • Bartlett, Illinois

FLEXIBLE METAL and SYNTHETIC HOSE EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

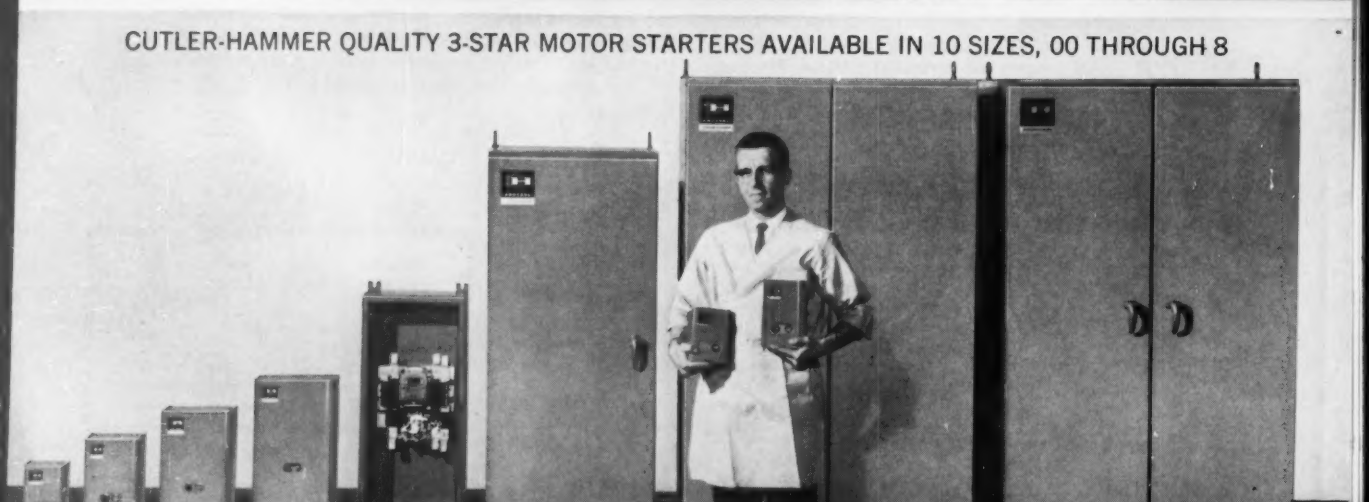
In CANADA
FLEXONICS CORPORATION OF CANADA, LTD.
BRAMPTON, ONTARIO

Flexonics
350 East Devon
Bartlett, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.



CUTLER-HAMMER QUALITY 3-STAR MOTOR STARTERS AVAILABLE IN 10 SIZES, 00 THROUGH 8



CUTLER-HAMMER MOTOR STARTERS

Still the proven standard of quality...always in stock for immediate delivery

Millions of satisfactory operations in thousands of applications have proved the unmatched quality of Cutler-Hammer across-the-line magnetic starters. That this line is still recognized as the leader—nine years after the original design was developed—is a great tribute to the years-ahead thinking of Cutler-Hammer engineers.

FIRST IN '53—STILL THE LEADER IN '61

Since the Three Star line was introduced in 1953, many improvements have been made; magnet coils that far exceed NEMA standards, for example. But many achievements of the original design—vertical, dust-free contacts; overload relays adjustable to within 3% of actual full-motor ratings; provision for 2 or 3-coil overload relays in the same enclosure—are features no other manufacturer has been able to improve. You can safely bet that when these pace-setting features are improved, it'll be another Cutler-Hammer development.

ALWAYS AVAILABLE FOR FAST DELIVERY

You'll find the smaller sizes of Cutler-Hammer Starters always in stock at your local distributors—larger sizes immediately available from the factory. We hope you'll make your own feature-by-feature comparison between the Cutler-Hammer line and any other starter on the market. Look especially carefully at such vital advantages as ease of installation, high interrupting capacity, coil construction and accessibility.

Regardless of what features you select as the criterion of superiority, we're sure you'll choose Cutler-Hammer after you've made your unbiased comparison.

If you're one of many companies being forced to stock two sets of parts because of design changes, now is an excellent time to standardize on Cutler-Hammer.

Call your distributor or local Cutler-Hammer Sales Office soon. Or write for Publication LO-70-Q243.

WHAT'S NEW? ASK..

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

Circle 269 on Page 19

REPUBLIC STEEL...

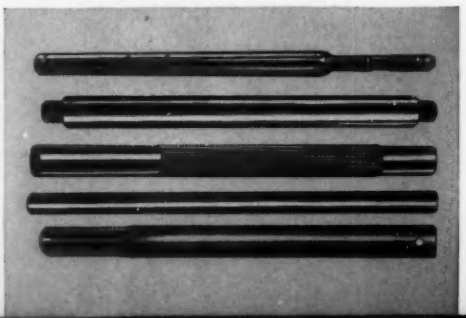
CARBON STEEL To ASTM A-178 BOILER TUBES	STAINLESS STEEL To ASTM A-269 CONDENSER TUBES				
STAINLESS STEEL To ASTM A-270 SANITARY TUBES	CARBON STEEL To ASTM A-214 HEAT EXCHANGER TUBES	STAINLESS STEEL Schedule 40S PIPE	CARBON STEEL To J.I.C. Standards HYDRAULIC FLUID LINE	STAINLESS STEEL Types 309, 309S, 310, 330 HEAT RESISTANT	CARBON STEEL Full Range of Sizes AIR PREHEATER TUBES
CARBON STEEL To 20" Periphery SQUARE TUBES	STAINLESS STEEL For Exhaust Stacks AIRCRAFT TUBES	CARBON STEEL Special Smooth I.D. CYLINDER TUBES	STAINLESS STEEL To ASTM A-269 EVAPORATOR TUBES	CARBON STEEL ¾" Thru 6" O.D. 16 Gage and Heavier HOT-ROLLED TUBES	STAINLESS STEEL Engineering Service SPECIAL SHAPES
STAINLESS STEEL Beading —Punching FABRICATED TUBES	CARBON STEEL For Corrosion METALLIZED TUBES	STAINLESS STEEL O.D.—I.D., or Both POLISHED TUBES	CARBON STEEL To 4"x6" Structural Grade RECTANGULAR TUBES	STAINLESS STEEL Including 4" O.D. BRIGHT ANNEALED	CARBON STEEL 22 to 10 Gage ⅛" Thru 6" O.D. COLD ROLLED TUBES
CARBON STEEL Also Stainless Steel GROOVED END TUBES	STAINLESS STEEL Round, Squares, Shapes ORNAMENTAL TUBES	CARBON STEEL Full Range of Sizes REFRIGERATION TUBES	STAINLESS STEEL Schedule 10S—5S LIGHTWEIGHT PIPE	CARBON STEEL To ASTM A-178 WATER WALL TUBES	STAINLESS STEEL Combination Stainless —Carbon CLAD TUBES
STAINLESS STEEL To ASTM A-249 HEAT EXCHANGER TUBES	CARBON STEEL Republic Spec-101 STRUCTURAL TUBES	STAINLESS STEEL To 5" O.D. MECHANICAL TUBE	CARBON STEEL Technical Assistance FABRICATED TUBES	STAINLESS STEEL Schedules 40S—10S—5S PIPE	CARBON STEEL For Mechanical Use MANDREL DRAWN TUBE

Steel

Strong, Modern, Dependable

PROBLEM-SOLVING KNOW-HOW AND EXPERIENCE have made Republic a leader in custom production of Fastener and Formed Parts "Specials." Whenever standard fasteners can't do the job, you'll save time and money by contacting Republic. Write for data on Republic design, engineering, and production services. *Circle 271 on Page 19*

TRIM COLD FINISHED BAR COSTS. Republic's CENTURY SERIES offers five grades of high-strength, stress-relieved, cold finished bars, each with a minimum yield strength of 100,000 psi. For highly machined parts, use C-1144. Moderately machined parts—C-1140 or C-1151. For parts where machinability is a minor factor—C-1050 or C-1045. Send for complete data. *Circle 272 on Page 19*



World's Largest Producer of SPECIALTY WELDED TUBING

Challenge us to come up with a solution to your toughest tubing applications.

We will produce the best possible answer drawn from Republic's full line of quality welded steel tubing and more than 50 years of applied engineering experience.

This claim is made with confidence. Our customers regularly hand us their tubing problems, and the results have provided mutual satisfaction.

Manufactured at the Steel and Tubes Division, Republic Tubing is welded by the ELECTRUNITE® process—a continuous electric weld method which unites the wall under pressure without foreign or extra metal. Among other advantages, this process assures uniformity of wall thickness, strength, ductility, and concentricity.

Republic, the pioneer in this improved welding process, was also the first to provide a non-destructive electronic production method of testing tubing used for critical pressure applications. This is known to the trade as FARROWTEST®.

Next time you have a tubing application or problem, take advantage of Republic's prompt delivery, engineering services, and complete range of carbon and stainless steels for mechanical, structural, and pressure uses.

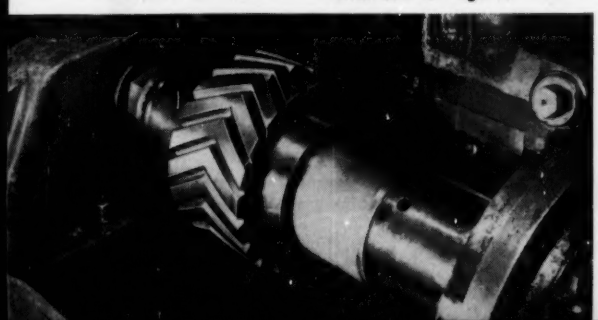
Call your nearest Steel and Tubes representative or contact us direct.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

FOR ADDED MACHINABILITY, consider Republic Cold Drawn Leaded Alloy Steels. Leading producers of gears use Republic Leaded Alloy Steel in the manufacture of heavy-duty herringbone gears. Addition of lead increases machinability as much as 25%. Heat treating assures adequate hardness and toughness. Cost-reducing Republic Alloys are available in almost every standard analysis and many specials. Mail the coupon for information.

Circle 273 on Page 19



Check this listing of Republic Steel Tubing and Pipe. Which have possible applications in your products?

STAINLESS STEEL

Pressure Tubing

- ☐ Condenser Tubes
- ☐ Pipe—Schedule 40S
- ☐ Sanitary Tubes
- ☐ Heat Resistant
- ☐ Evaporator Tubes
- ☐ Bright Annealed
- ☐ Pipe—Lightweight Schedule 10S—5S
- ☐ Heat Exchanger Tubes

Mechanical Tubing

- ☐ Aircraft Exhaust
- ☐ Special Shapes
- ☐ Fabricating Facilities
- ☐ Polished Tubing
- ☐ Ornamental Tubing
- ☐ Clad Tubing Carbon—Stainless

CARBON STEEL

Pressure Tubing

- ☐ Boiler Tubes
- ☐ Heat Exchanger Tubes
- ☐ Hydraulic Fluid Line
- ☐ Grooved End Tubes
- ☐ Refrigerator Tubes
- ☐ Water Wall Tubes
- ☐ Superheater Tubes
- ☐ Condenser Tubes
- ☐ Evaporator Tubes

Mechanical Tubing

- ☐ Air Preheater
- ☐ Square Tubes
- ☐ Rectangular Tubes
- ☐ Special Smooth I. D. Hydraulic Cylinder Tubes
- ☐ Hot Rolled Tubes
- ☐ Cold Rolled Tubes
- ☐ Metallized Tubes
- ☐ Structural Tubes
- ☐ Fabricating Facilities
- ☐ Drawn Tubes

Cut out and send this check list for descriptive literature on Republic Tubing and Pipe applicable to your products.

Circle 274 on Page 19

REPUBLIC STEEL CORPORATION
DEPT. MD-2158
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please also send me information on:

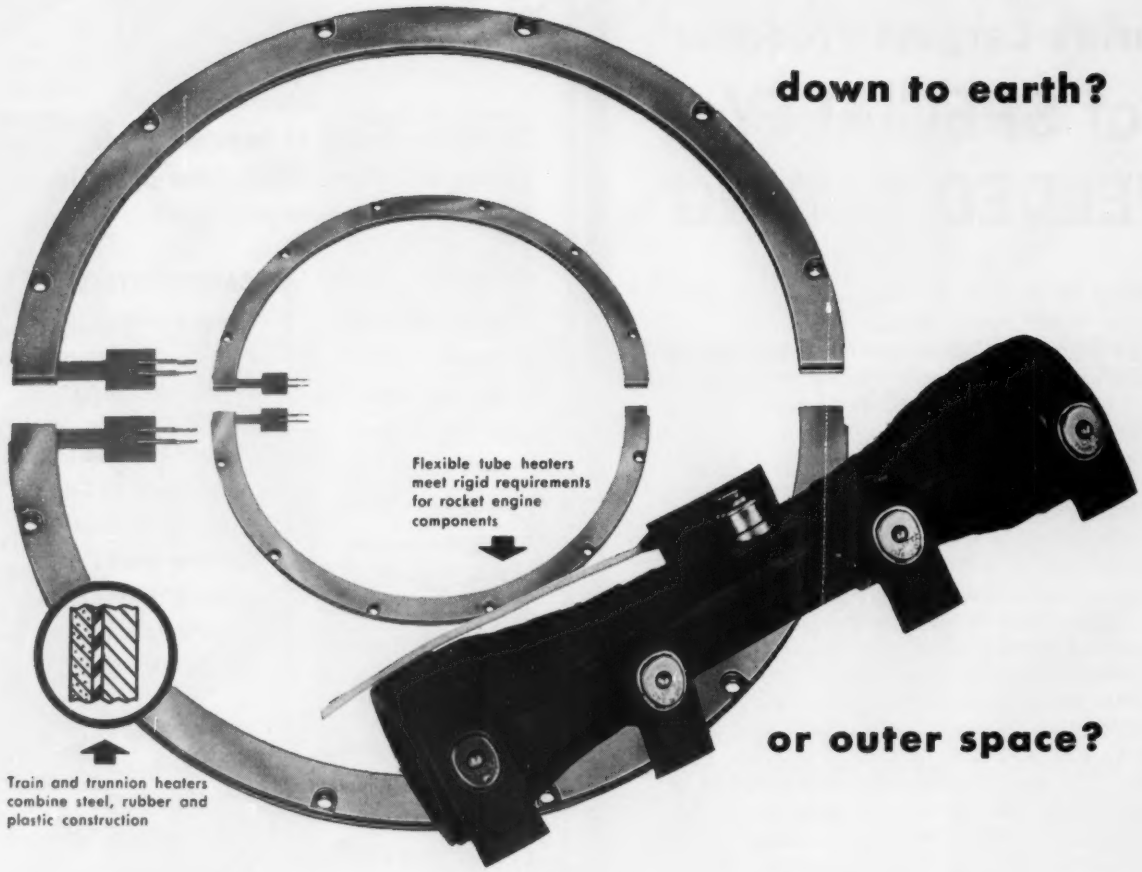
- ☐ Republic Cold Drawn Leaded Alloy Steels
- ☐ Republic Formed Part "Specials"
- ☐ Republic Century Series

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____


down to earth?
Flexible tube heaters meet rigid requirements for rocket engine components
or outer space?
Train and trunnion heaters combine steel, rubber and plastic construction

SAFEWAY Heat Elements apply engineering imagination to all defrosting, de-icing and heating problems

Unusual and intricate *cold-control* problems frequently find their way to us. The circular heat elements shown above are components of vital ground support equipment. Exacting specifications called for the "sandwiching" of a continuous, circular heating element between two rings of different materials. The actual heating element is encased in silicone rubber and then bonded under controlled heat and pressure to two external rings: one of *silicone-resin impregnated fiberglas* and the other of *stainless steel*. The completed unit must withstand lengthy soak-testing in a salt water solution. Outside diameters of the train and trunnion rings are 56 7/8" and 29 3/8", respectively.

The flexible tube heater illustrated is another successful solution to a complex flight propulsion system heating problem. In this instance, custom-made flexible tube heaters have resistance wire molded in silicone rubber. Result—uniformly *dependable* heat is provided for rocket engine components.

MEETS THE MOST SPECIALIZED REQUIREMENTS

Safeway's long-term military and industrial experience backs up the production of thoroughly reliable heating, de-frosting and de-icing units —*woven, molded* or *strung*—for scores of different applications. So, if *cold-control*—of any description—is on your "problem list", write or phone us. Chances are excellent we can help you.

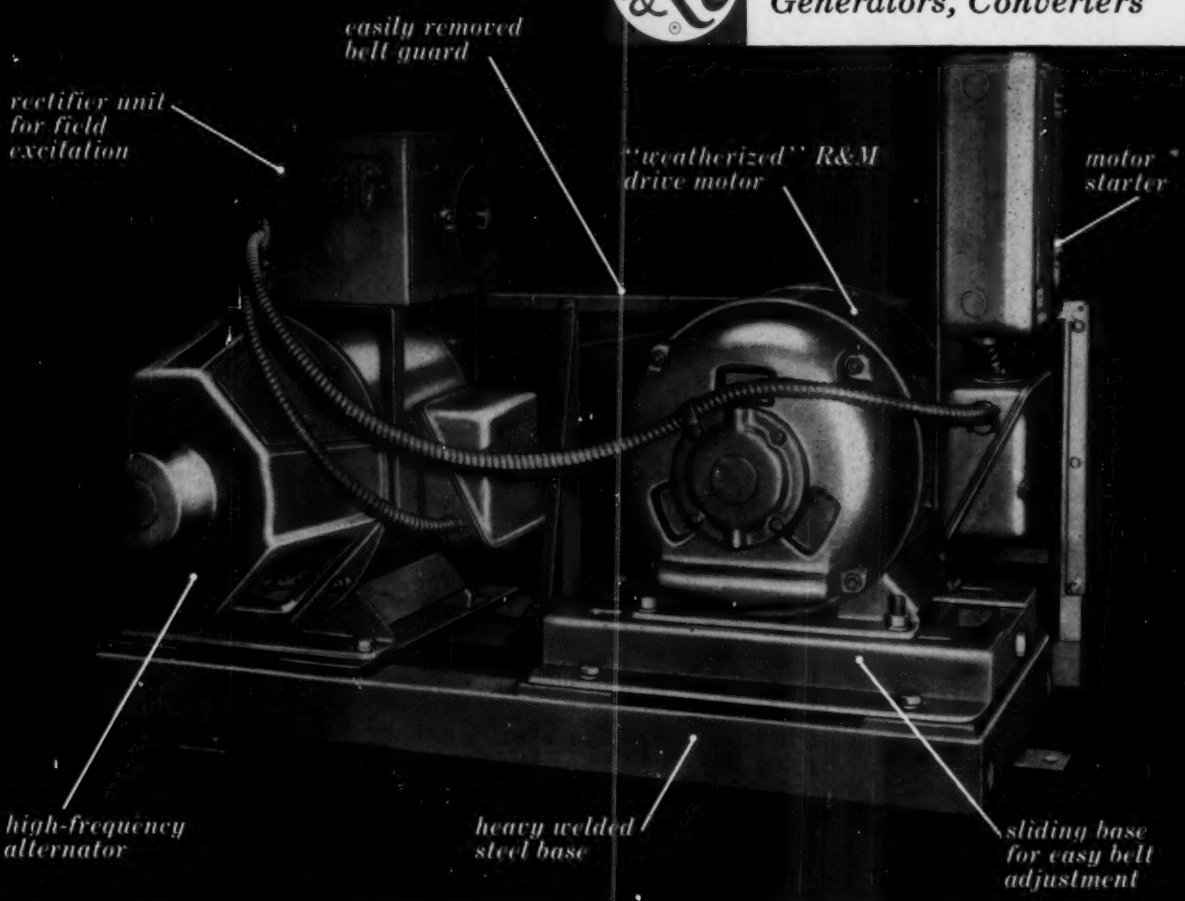
Write today for our fact-filled brochure, describing the wide range of materials, specifications and application possibilities. Safeway engineers will gladly analyze your requirements and submit practical recommendations

Safeway HEAT ELEMENTS INC.

Middlefield Street • Middletown, Connecticut

high frequency

Generators, Converters



Compact High Frequency Power Generators

360 to 3300 cycles

R&M package high cycle generators provide dependable current beyond the practical range of frequency converters. Rugged revolving field construction is used in ratings of 1500 cycles and lower. Ratings above 1500 cycles are brushless inductor design. Excitation of DC alternator field is provided by simple silicon rectifiers, protected against short circuits by time-delay fuses. For changing output frequency, R&M can furnish variable pitch pulleys or variable speed drives. R&M's low-cost frequency converters make 220 volt-3 phase-120 through 420 cycle power available from 60 cycle supply . . . rated 2½KW (horizontal construction) 5, 7½ and 10KW (vertical).

Write today for bulletin 515A-MD!

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 276 on Page 19

For Long Life and Power Economy

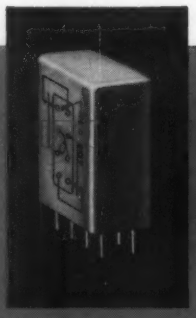
Specify the ***NEW***

CLARE *LATCHING SUBMINIATURE crystal can* ***RELAY***

The new CLARE Type LF, magnetic latching subminiature relay offers designers simplified circuitry in small space by providing latching effect without transistors. Magnetic latching results in power economy.

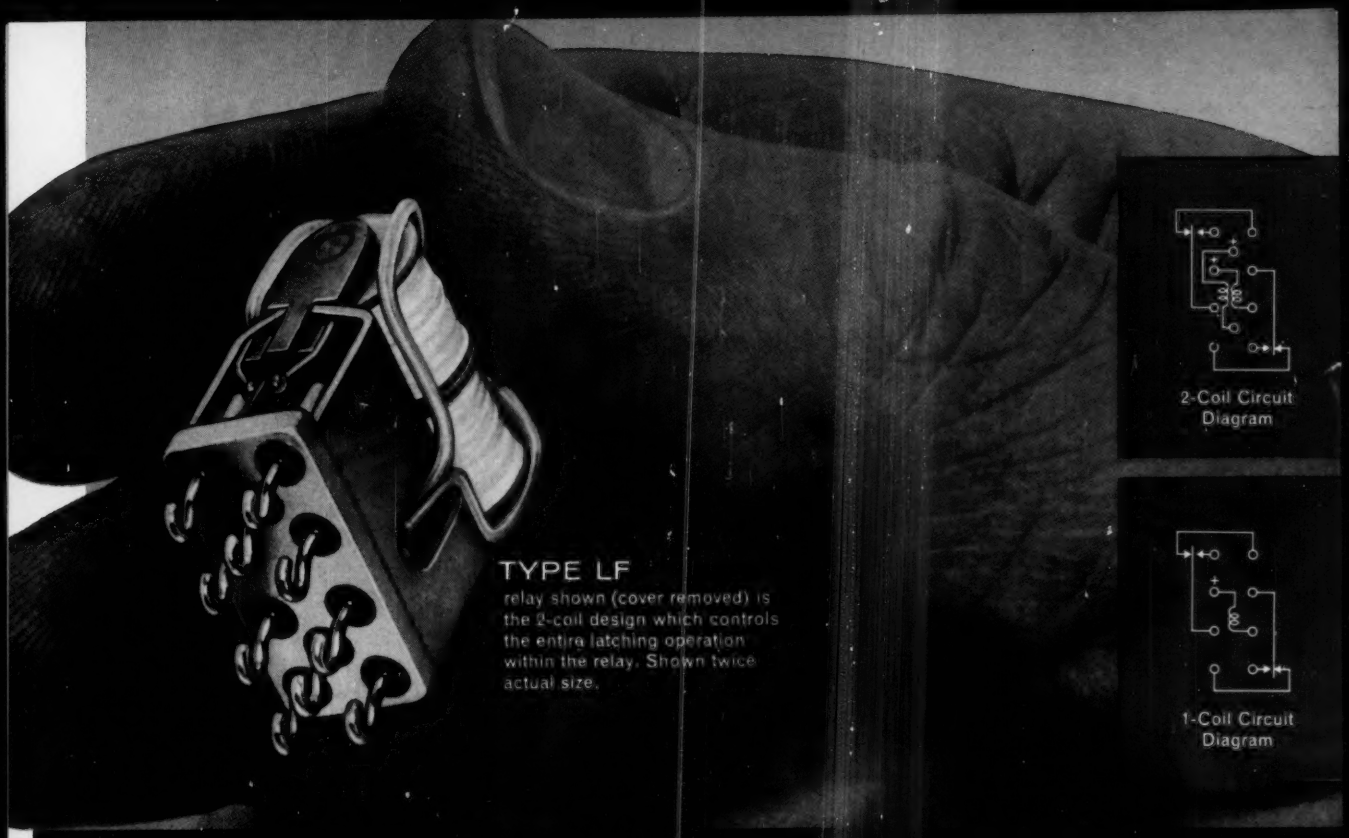
The Type LF is available with either 2-coil or 1-coil configuration. The 2-coil relay allows complete control of the latching operation within the relay and provides an extremely compact operating unit. The 1-coil relay is somewhat more sensitive; it is adaptable to existing circuits where outside control is provided. (See opposite page for specifications and circuit diagrams.) The Type LF provides the same wide range of mounting arrangements and terminals as the CLARE Type F relay.

FOR NON-LATCHING OPERATION



CLARE Type F Subminiature Crystal Can Relay

The CLARE Type F relay is extremely fast and more than moderately sensitive. It is built to withstand temperature extremes, heavy shock and extreme vibration. Contacts, rated at 3 amperes, are excellent for low-level circuit operations. Send for Design Manual 203.



TYPE LF
relay shown (cover removed) is the 2-coil design which controls the entire latching operation within the relay. Shown twice actual size.

2-Coil Circuit Diagram

1-Coil Circuit Diagram

PHYSICAL FEATURES

Life Expectancy
Wet Circuit:
3.0 amperes, 28VDC resistive—100,000 operations
2.0 amperes, 28VDC resistive—250,000 operations
1.0 ampere, 28VDC resistive—1,000,000 operations
1.0 ampere, 28VDC inductive (100 millihenry)—100,000 operations
1.0 ampere, 115 VAC resistive—100,000 operations
Dry Circuit:
1,000,000 miss free operations when subject to conventional dry circuit requirements.

Temperature—+125° C to −65° C

Shock—100g's for 1/2 sine wave 11± 1 MS pulse

Linear Acceleration—100g's minimum

Vibration—.250" DA or 30 g's, 5-2000 cps.

Humidity & Salt Spray—MIL-R-5757D

Enclosures: Tinned brass cover with fungus-resistant finish. Hermetically sealed and filled with dry nitrogen at atmospheric pressure.

Contact Arrangement—2PDT latching

Terminals—Plug-in (3/16" straight), solder hook, 3" straight

Wiring—Two coils (as shown on drawing above)
One coil (as shown on drawing above)

Weights—.54 oz. for plug-in
.62 oz. for 2 studs, 3" leads

ELECTRICAL FEATURES

Operate Time—Two coil: When applying—for a minimum of 5 milliseconds—a voltage of at least two times the must operate voltage, the operate time including bounce will not exceed 5 milliseconds. One Coil: operate time will not exceed 8 milliseconds.

Sensitivity—Two coil, approximately 150 milliwatts
One coil, approximately 75 milliwatts

Dielectric Strength
Sea level: 1000 volts rms—all terminals to case
1000 volts rms—between contact sets
600 volts rms—between open contacts of a set
70,000 ft: 350 volts rms—all terminals to case

Insulation Resistance—1000 megohms minimum at +125° C between any two terminals and between all terminals and case.

Maximum Interelectrode Capacitance—
Closed contacts to case.....3.7 picofarads
Open contacts to case.....2.0 picofarads
Between contacts of a set.....2.0 picofarads
Between adjacent contact sets.....3.5 picofarads

Maximum Coil Dissipation
Two Coil: .50 watts at +125° C
.75 watts at +25° C
One Coil: 1.25 watts at +125° C
2.0 watts at +25° C

Standard Adjustment—Relay will operate and hold when the must operate voltage is applied

Contact Resistance:
Maximum: 50 milliohms at 6 volts, 100 milliamperes.
Typical: 25 milliohms at 6 volts, 100 milliamperes.

For coil and mounting data on CLARE Type LF relay send for CPC-12. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ontario. Cable Address: CLARELAY.

C. P. CLARE & CO. *Relays and related control components*

Circle 277 on Page 19

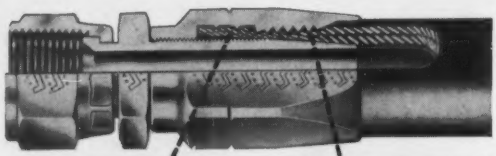
WHAT IS YOUR BEST BUY IN REUSABLE HOSE FITTINGS?

Compare

STRATOFLEX

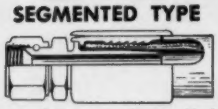
with three other types for the answer!

STRATOFLEX "SCREW-TOGETHER" TYPE



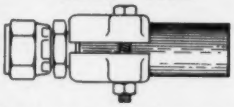
- Minimum envelope dimension
- No special tools required for assembly or disassembly
- Uses standard hose
- Complete reusability
- Pressure rating equal to burst of hose
- Uniform compression
- Long life proven in service

SLEEVE AND SEGMENTED TYPE



Wire exposed to corrosion • Limited reusability of segments • Large envelope dimension • Special tools and/or equipment required for assembly and disassembly • Non-uniform compression • Limited service history

CLAMP TYPE



Doesn't grip wire • Limited pressure rating • Large envelope dimension • Non-uniform compression • End of hose exposed to corrosion

NON-SKIVE TYPE

High assembly torques • Inconsistent grip of wire • Uses non-standard thin covered hose which has critical tolerances • Special tools required for proper assembly of hose to socket

SF5-1

STRATOFLEX Inc.

P.O. Box 10398 • Fort Worth, Texas
Branch Plants: Hawthorne, Calif., Fort Wayne, Ind.
In Canada: Stratoflex of Canada, Inc.
In Great Britain: Stratoflex (U.K.) Ltd.

SALES OFFICES:
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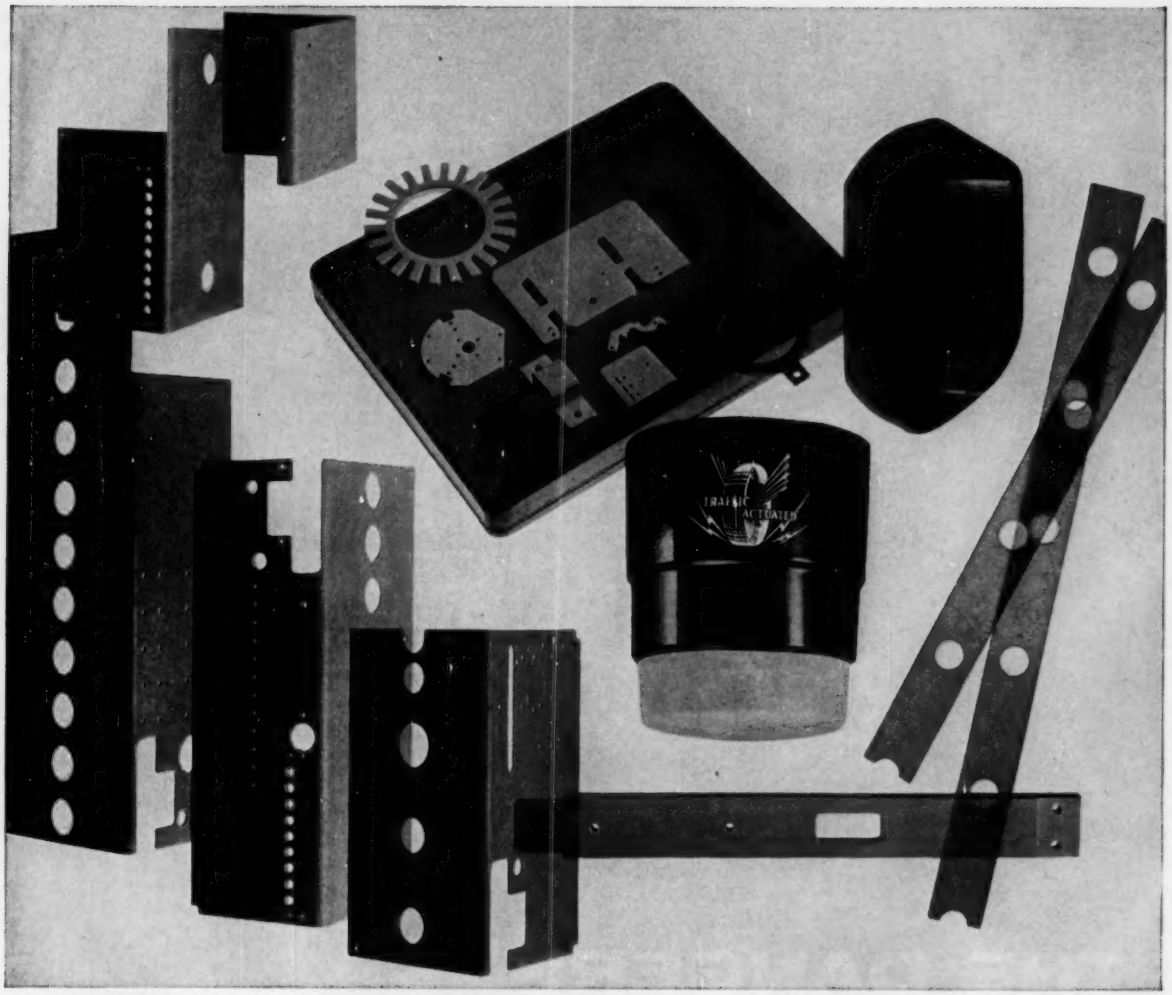
Cleveland, Dayton, Denver
Detroit, Fort Wayne
Fort Worth, Hawthorne
Houston, Kansas City
Milwaukee, New York
Orlando, Philadelphia
Pittsburgh, San Diego
San Francisco, Seattle
Toronto, Tulsa

For complete information, write for Stratoflex Catalog 201.



Have you explored the full design potentials of molded polyester-glass?

Few materials offer the designer so many opportunities for product design simplification and cost reduction.

Added to the inherent toughness and strength of polyester-glass are good electrical and thermal properties, weather resistance—and flame retardance if you need it.

Using advanced molding and machining techniques, complex shapes and structures can be produced to reduce product weight or the number of parts, eliminate costly machining or stamping operations, simplify product assembly, improve product performance, life, or reliability.

These are the kinds of results our customers are achieving. For a few thought-starters—and facts about NVF polyester-glass products and molding services—contact your nearby NVF Sales Office, or write for our new folder, Dept. G-8, Wilmington, Delaware.

116 Choices: One Source This is the latest count of the different plastics and grades NVF can offer in your search for the *one best material.* Add to this total *the* one special grade that can be developed from scratch to meet your particular need. This full range of materials is backed by complete engineering services . . . from application assistance up to and including the delivery of 100% usable, precision-fabricated parts . . . in any quantity, on time!

Call the NVF Sales Office near you. It's a direct line to single-source help on your current materials problem.

NVF

NATIONAL VULCANIZED FIBRE COMPANY
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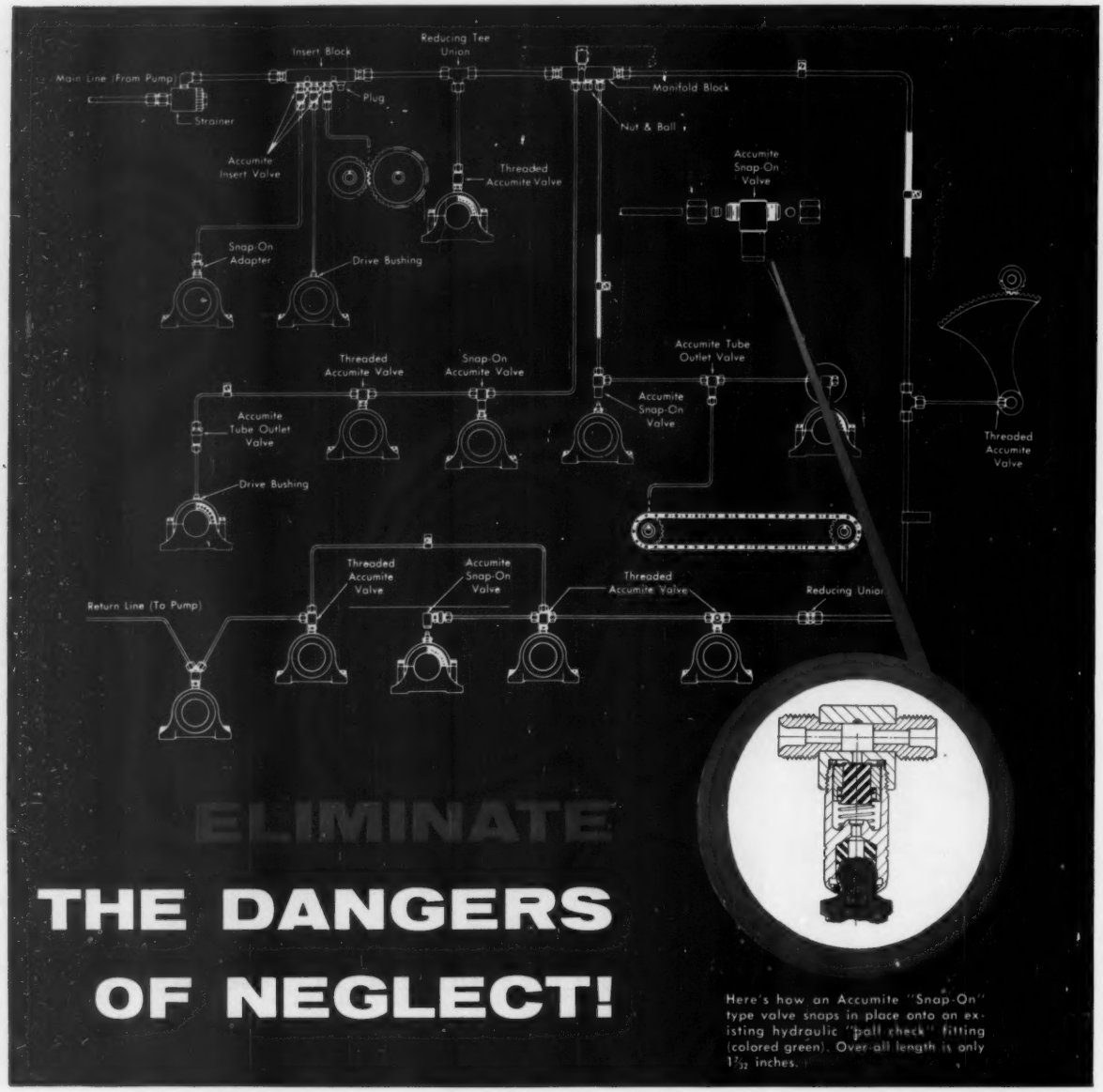
Circle 279 on Page 19



Alemite Accumite® Centralized Lubrication System avoids costly breakdowns, work-stoppage. Automatic positive lubrication protects all machines!

The Alemite Accumite® Centralized Lubrication System comes complete with pump, metering valves and controls. Meters exact amount of lubricant to all bearings whenever system is operated by air, vacuum or manually at any predetermined frequency.

There's no need for a lubrication shutdown. No chance of work spoilage or bearing failure due to over lubrication. The Alemite Accumite System accurately meters .003, .006 or .009 cu. in. shots of oil or grease automatically. Is available with adjustable fittings for applications requiring measured metering from .003 cu. in. to zero. "Snap-On" and "Screw-In" type valves make for complete flexibility in converting existing systems to automatic operation.

You are assured economical, trouble-free operation of equipment. All bearings are sealed against dirt, grit and water. You are able to eliminate the dangers of neglect because all bearings receive proper lubricant in one, automatic, safe operation!

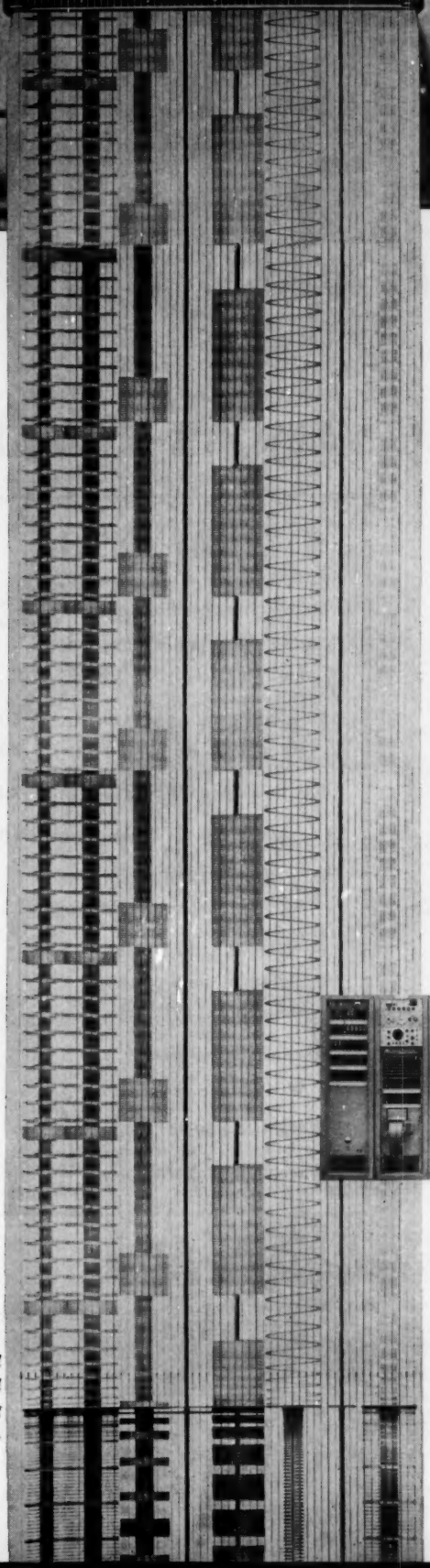
For complete details on Alemite Accumite® Centralized Lubrication Systems for large or small, stationary and mobile equipment (Canning and Labeling Machines • Tractor Trailers and Lift Trucks • Farm Implements • Machine Tools • Textile Machines • Any Machine or Vehicle with Moving Parts) write for your *FREE* Alemite Accumite Catalog . . . today!

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

1850 Diversey Parkway, Chicago, Illinois

Visicorder and record shown approx. ½ actual size.



Record speed changed during recording.

"MASTER CLOCK"

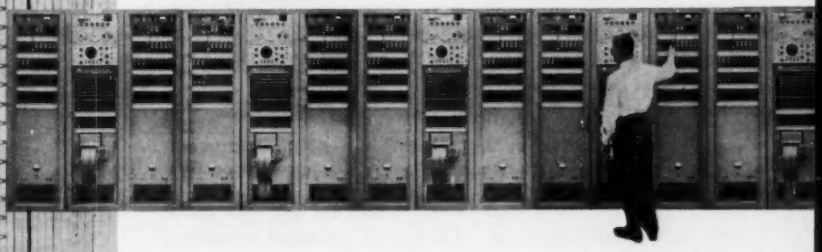
for the missile range uses 15 Honeywell Visicorder oscillographs

The Timing Operations Center designed and built by Epsco-West for the Navy's Pacific Missile Range is now in use at Point Mugu, California. It makes use of 15 Honeywell Visicorders to read out (as shown on the unretouched record at left) the modulated timing codes distributed as balanced outputs to the Center's "customers."

The solid-state Epsco-West TOC generates up to 11 separate timing signals, one or all of which may be delivered to any of 36 users.

The 906B Visicorder also performs a supplementary function as a monitor on the timing and test-patch panel, and as permanent "record-keeper" for the built-in indicators and test oscilloscopes. Visicorders were selected for their jobs with the TOC because of their versatility, reliability, low cost, and compact size ((10″ x 10″ x 15½″; weight, 37 lbs.).

Pioneer and acknowledged standard in the field of high frequency direct-recording oscillography, the Visicorder is available in several models, from 6 to 36 channels, DC to 5000 cps response, up to 50,000″/sec writing speed. Honeywell engineering is at your service through 120 field offices for help in applying one Visicorder or a full system to your data acquisition program; or a quantity of Visicorders for OEM application in your products.



Call your local Honeywell office now or write today for Catalogs HC906B, 1012, 1108, and 1406 to Minneapolis-Honeywell, Heiland Division, 5200 East Evans Avenue, Denver 22, Colorado. Our telephone is SKyline 6-3681, Area Code 303.

Honeywell

First in Control

SINCE 1885

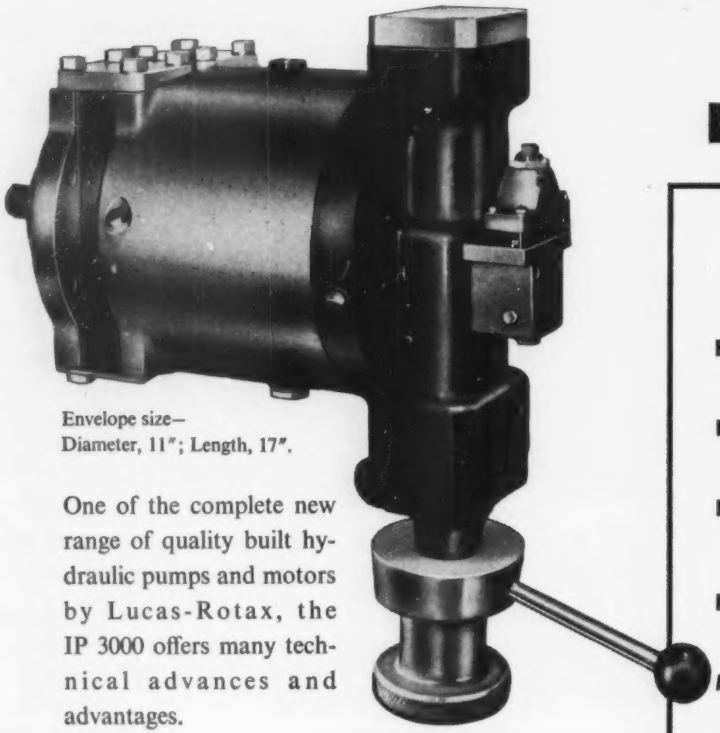
Circle 281 on Page 19

Unmatched in performance, quiet... the reliable

NEW IP 3000 INDUSTRIAL HYDRAULIC PUMP

by

LUCAS-ROTAX



Envelope size—
Diameter, 11"; Length, 17".

One of the complete new range of quality built hydraulic pumps and motors by Lucas-Rotax, the IP 3000 offers many technical advances and advantages.

- Smaller size
- Lower weight
- Variable volume
- Low noise level at higher operating speeds
- Low cost
- High efficiency
- Fitted with pressure compensator as standard equipment

For further information, contact the agent or office nearest you today, or write for technical literature.

PUMP DETAIL

	Basic Pump Fixed Stroke
Fluid displacement (cub. ins./rev.)	13.89
Nominal working pressure (peak)	5000
(lb. per sq. in) (continuous)	3000
Nominal speed (peak)	2000
(r.p.m.) (continuous)	1800
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	38
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	200
Recommended Inlet Pressure (p.s.i.g.)	60
Weight (lb.) Basic Pump	128
Operating temperature	—40 to 200°F

a product of creative engineering by

LUCAS-ROTAX LIMITED, TORONTO

LUCAS ROTAX

A member of the Lucas organization
WITH OFFICES AND SERVICE DEPOTS THROUGHOUT NORTH AMERICA

BOSTON • NEW YORK • CHICAGO • LOS ANGELES • HOUSTON • SAN FRANCISCO • CLEVELAND
JACKSONVILLE • DENVER • SEATTLE • BALTIMORE • TORONTO • MONTREAL • VANCOUVER

6010

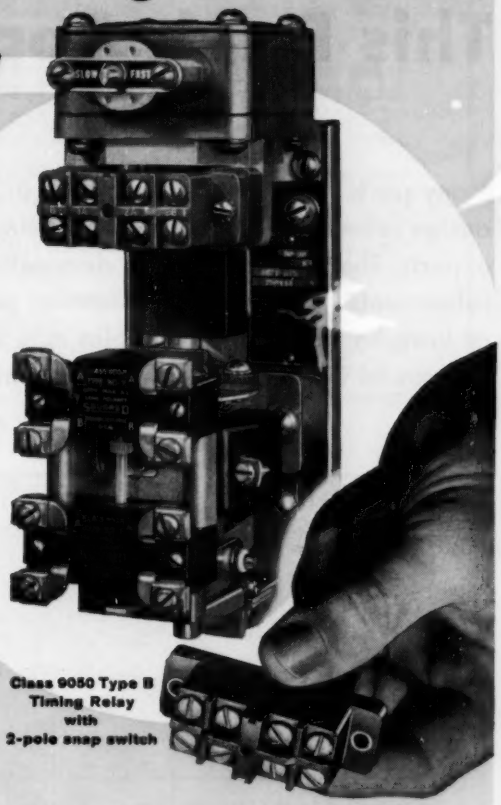
TWICE as many Timing Contacts

—SAME PANEL SPACE!

For extra timing contacts, it's no longer necessary to buy a second timer or extra relay. Square D's Class 9050 Types B and C timing relays are now available with the new 2-pole snap switch which doubles the number of contacts you get with the single-pole device—and mounts in exactly the same space! What's more, totally enclosed contacts eliminate dust and dirt problems.

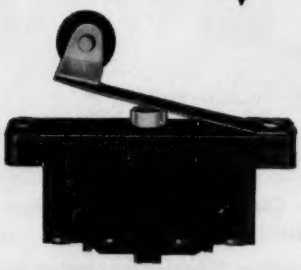
The 2-pole version also offers the same advantages as the single-pole timer:

- Easily converted from on-delay to off-delay or vice versa
- One or two single-pole double-throw instantaneous snap switch interlocks
- Timing period adjustable from 0.2 seconds to 3 minutes
- Available for either AC or DC
- All contact terminals out front for easy wiring
- Wide variety of enclosures for any application

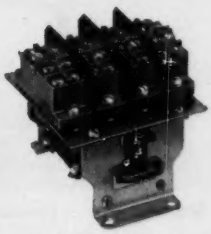


Class 9050 Type B Timing Relay with 2-pole snap switch

ALL THESE DEVICES NOW AVAILABLE WITH 2-POLE SNAP SWITCHES

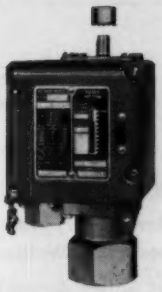


Basic 2-pole snap switch available, or with a variety of operators



Type P relay offers 16 contacts (8 N.O. and 8 N.C.) in one compact unit occupying less than 14.5 square inches of panel space

Limit switch is the most oil-tight of any you can buy



Industrial-type pressure switch offered with operating range to 15,000 lbs

Write FOR DETAILS on Square D 2-pole devices shown. Square D Company, Dept. SA, 4041 North Richards Street, Milwaukee 12, Wisconsin

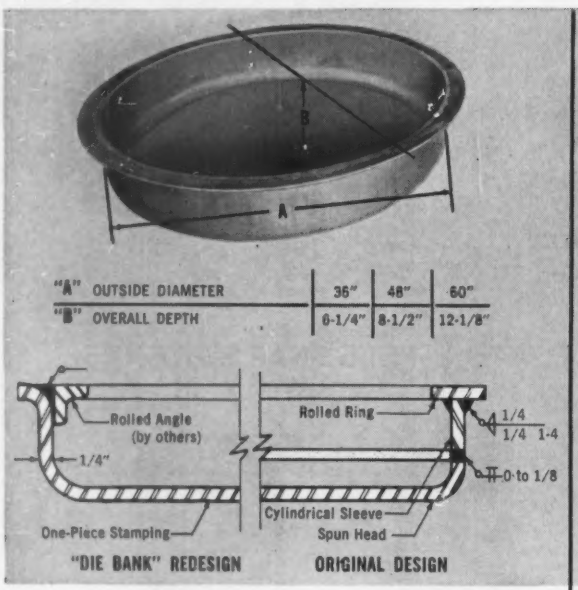
SQUARE D COMPANY

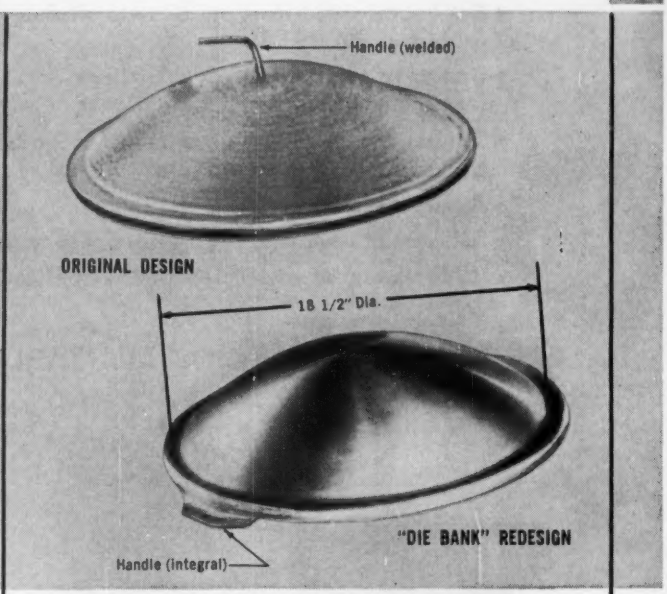
wherever electricity is distributed and controlled

Circle 283 on Page 19

How to Improve Parts Design with This Fresh Approach to Stamping

Many parts in use today are better as a result of design refinements suggested by COMMERCIAL's stamping experts. The examples below demonstrate how these design refinements have resulted in superior parts for the OEM at lowered cost. These examples may appear to you as unusual in design and this is the point...





One Piece Stamping . . . Improves Appearance, Replaces Three Piece Weldment

Circular steel boiler doors 36", 48", 60" diameter were formerly fabricated from three basic components—spun head, cylindrical sleeve and ring rolled the hard way.

Problem: eliminate accumulative assembly variables caused by inherent non-uniformity of three components—upgrade product appearance.

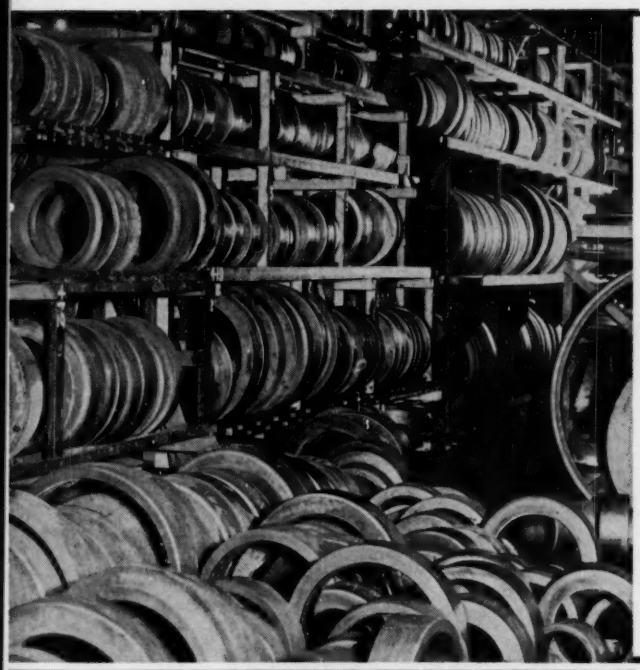
Solution: one piece smooth surface COMMERCIAL steel stamping shaped in a die assembled from stock "die bank" components (for details of "die bank", see box upper right). Stamping tolerances plus or minus 1/16" (flat across flange within 1/16"). Result—accurate finished product because former difficult assembly and time-consuming fitting-up problems eliminated. All outside exposed welds (about 16 ft. on the 48 in. side) and grinding discontinued. An end product with improved appearance—better product appeal.

Stampings . . . Unitize Construction, Replace Inaccurate Stainless Steel Spinnings

Original contruction of bulk milk cooler used tank manhole cover spinning—requiring welding, grinding and polishing.

Problem: reduce production finishing time, overcome welding heat distortion of stressed metal-spinnings, increase strength, produce uniform parts and improve sanitation properties.

Solution: COMMERCIAL's "die bank" proved a nucleus for a one-piece stamping redesign including integral handles. Basic stamping details—size, shape and gauge were tailored to stock die components. Realization—smoother finish of stamping creates a more sanitary, better appearing tank. Closer tolerances of stamped cover provide flange with definite "drop-on" vacuum seal. Fewer parts resulting from stamping. Unitization greatly diminishes production time and component cost.



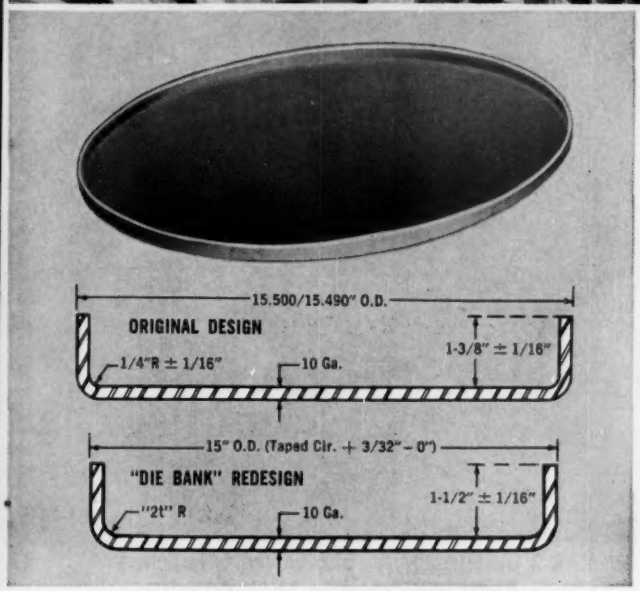
"Die Bank" Facts

Over 50,000 stock die components stand ready to go to work for you at COMMERCIAL. These components can be combined in endless variety—can prove, as they have for others, invaluable in your stamping design.

Components for circular stampings cover a diameter range from 2½" to 72". To 30" O.D., increments are in units of 1". Over 30" O.D., increments progress from 1" up to 6" for the largest diameter. Under 24" O.D., many sizes are available in fractional inches.

Stampings from these die components range from 20 gauge to ¾" thick. Contour can be flat or dished to any one of many patterns. Stampings can be supplied with vertical, horizontal or reverse flanges—or without any flange.

Use of COMMERCIAL's "die bank" results in many stampings made to basic original design free of heavy tooling cost—minor design latitude often eliminates all die expense. Catalog 200-C1 "Standard Metal Shapes" should be in your hands when preliminary designs go on the board.



"Die Bank" Stamping Gets O. K. . . .
Reduces Cost of Tailored Design

Original design of agriculture combine cylinder head called for odd fractional dimensions. Tolerances were tighter than necessary and applied in conflict with best stamping practice. Details were established without knowledge of COMMERCIAL's "die bank". Result—high unit cost to produce basic part to individually tailored size. Special dies, not in existence, were required.

Problem: redesign a more practical part to be mass produced at low unit-cost—eliminate special die cost.

Solution: simple redesign using stock die components from COMMERCIAL's "die bank" cancelled out $1850 partial die cost required for tooling original design. Net die cost: zero. Piece price reduced: 16 cents. Savings on initial requirement: over $2200. A stamping made to commonly accepted tolerances at lower cost without sacrificing product quality was the answer.

Advantages of Stampings

Economy of production
—metal conservation, waste material minimized, stamped parts have greater surface area than blank the part is made from—without loss in strength
—high quantity man-hour output from fast production machines—low unit cost

Greater strength: predicted, controlled, unvarying
—higher proportionately, in relation to weight, than possible in other metalworking processes

Enhanced appearance: finish is predictable, uniform, "as specified"
—multiple selection of basic material and its finish facilitates maintaining appearance in stamping the part or its further processing

Features of COMMERCIAL Stampings

Specialized equipment
—modern presses with capacity over 2000 tons; facilities located in three strategic metal producing centers

Economical large or small runs
—medium to heavy, shallow or deep drawn stampings

Facilities for finishing
—drilling, boring, tapping, machine trimming, burning, welding, painting, etc.

While designs are on the board, or redesign of parts in usage are fresh in mind, why not call on COMMERCIAL'S technical service—send print, sketch, sample or prototype. Address: Commercial Shearing & Stamping Company, Dept. S-33, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

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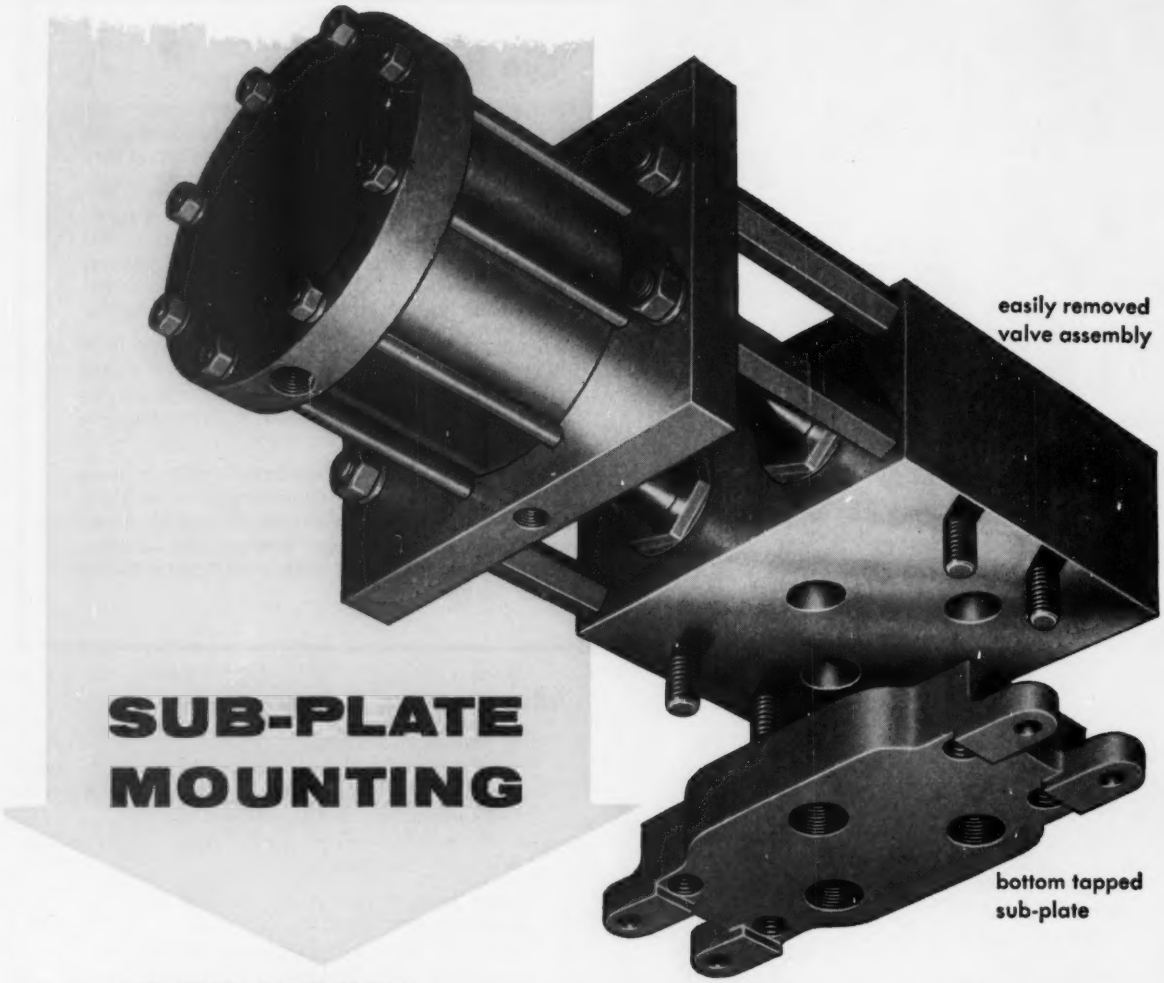


SUB-PLATE MOUNTING

for HUNT Hydraulic Valves

- ***easier maintenance***
- ***minimum downtime***

Designed to fit into today's preventive maintenance programs, Hunt's new sub-plate mounting permits quick valve removal and installation.

With sub-plates, equipment downtime is cut to an absolute minimum . . . valves can be repacked in your maintenance shop instead of on the machine. And, once installed, permanent piping need never be disturbed.

O-ring seals between valve body and cast steel sub-plate assure leak-free sealing . . . bottom tapping of sub-plate affords maximum access to valves and eliminates piping clutter.

Sub-plate mounting is available on all ½ through 2 in. Hunt hydraulic valves.* To learn more about the performance and cost-cutting advantages of Hunt valves, contact your nearby Hunt representative.

*Except those with cast or forged bodies.

HUNT

QUICK-AS-WINK® AIR AND HYDRAULIC

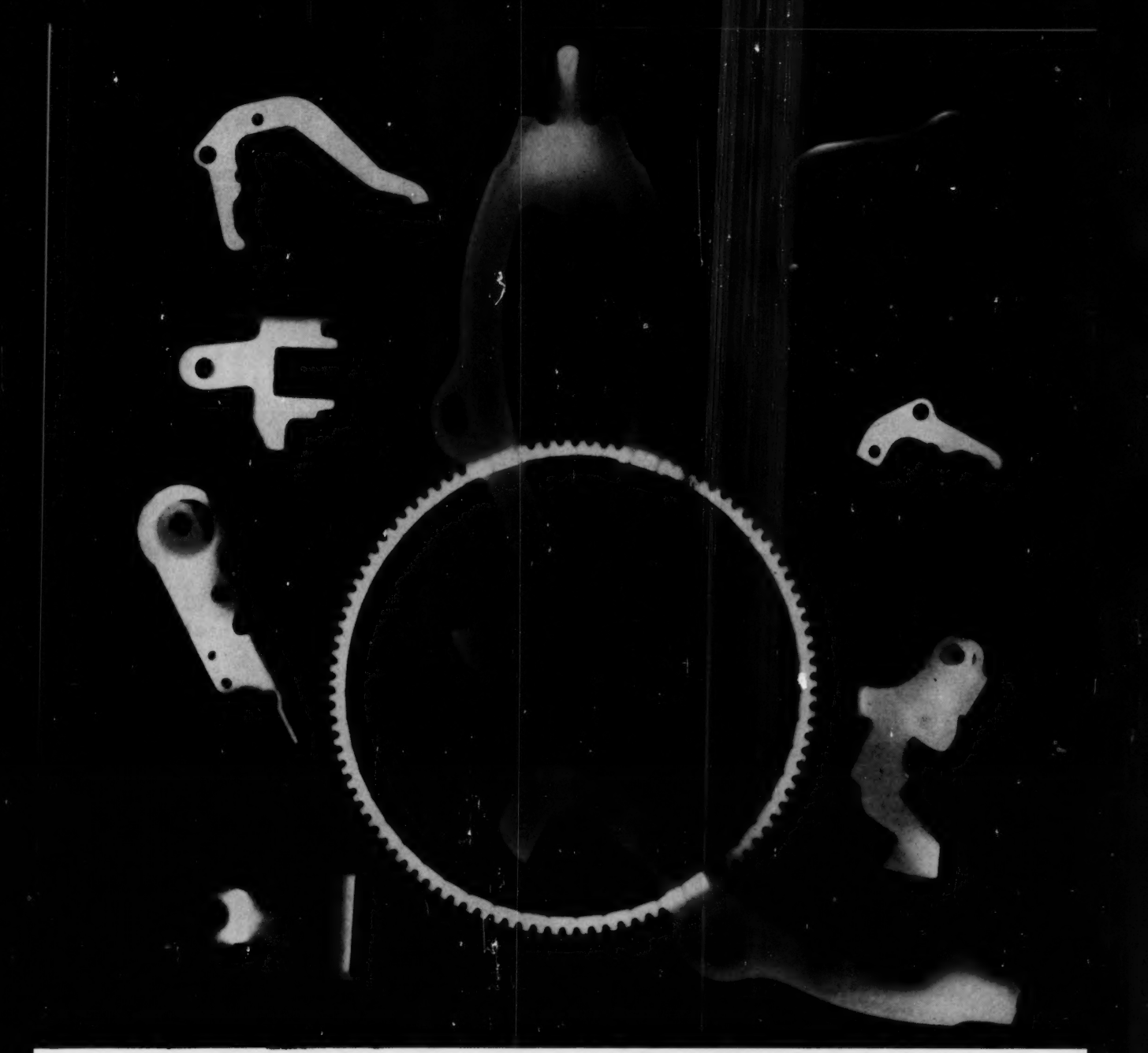
VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

Want more detailed information? Write Dept. MD-861, Hunt Valve Company, Salem, Ohio. Ask for Bulletin 604.

3002

Circle 285 on Page 19



WHICH OF THESE STAMPINGS COSTS LESS WITH PRECISION STEEL?

All of them, as a matter of fact. The design requirements of the finished parts may—or may not—call for closer than standard tolerances. But in an intricate, high-speed operation, a variation of 0.003" could result in costly production problems—frequent delays, constant tool adjustment, a high percentage of rejects, etc.

With J&L strip steel cold rolled to precision tolerances, you can expect uniform, trouble-free stamping. The reduced production costs plus the increased product reliability will more than offset the slightly higher initial cost of precision steel.

The key to J&L's superiority in strip steel processing is its ability to produce to standards more exact and precise than those in general use.

J&L's combination of specialized equipment and techniques, plus *experience*, are available to solve your stamping problems. For information, call your J&L Stainless and Strip Division representative or write to Dept. 1359.

Steel

J&L STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Circle 286 on Page 19

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

new–lube-free...

STERLING
Sealed and shielded bearings require no lubrication.
Keys are fabricated from tough elastic material to eliminate key and keyway wear.
Wear-resistant non-metallic bushings require no lubrication.
Shaft surfaces are corrosion-proof and require no lubrication.
CAUTION

...Sterling's variable speed drive never requires lubrication

Costs Reduced—One of management's biggest headaches has been the development and maintenance of proper lubrication schedules. As a consequence, lubrication problems have long been the cause of variable speed drive failures, pulley wear, sticky pulleys, shortened belt life, excessive noise, and many other equally costly problems.

High labor costs, coupled with increased maintenance needs, are major management problems.

Lubrication Eliminated—Now, Sterling has eliminated all lubrication maintenance problems. No part of a Sterling variable speed drive needs to be lubricated.

All bearings, sealed and shielded, are factory-lubricated and therefore require no lubrication. Shaft surfaces are impregnated with a special exceptionally tough and wear-resistant material which eliminates need for lubrication. The non-metallic bushings are also fabricated from a special material that is equally wear-resistant.

Special Load-Bearing Surfaces—At no time do these surfaces require any attention. Even the keys are fabricated from a tough elastic material and will not wear out.

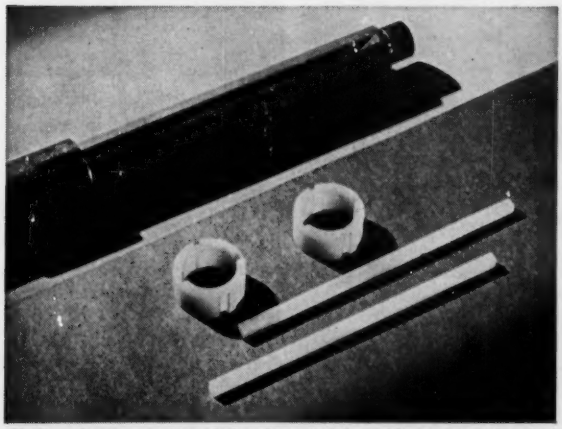
Fret corrosion, long a problem with metallic load-bearing surfaces, is completely eliminated since non-metallic surfaces now carry the load. Sticky pulleys, frequently the result of improper lubrication, are no longer a problem.

Sterling's new "Lube-Free" variable speed drive can be installed in any location, no matter how inaccessible, since lubrication maintenance is no longer needed.

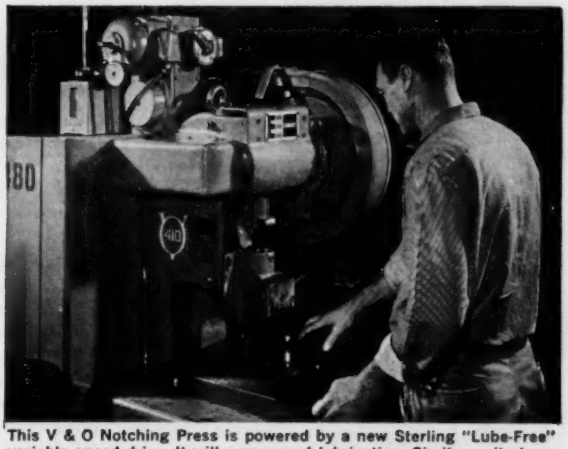
Other Benefits—Costs are reduced, money saved, when lubrication maintenance is no longer necessary. Belt life is lengthened; pulley wear is eliminated. Bearing life may also be lengthened by the elimination of worn pulleys—often the cause of vibration and bearing wear.

All other Sterling variable speed advantages are present in this new "Lube-Free" drive: wide range of speeds, heavy duty cast iron case, finger-tip speed control, etc.

Information Available—Complete application and product information is available by writing Dept. D-4, Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles 22, California—or by contacting the Sterling field engineer in your area.



Shaft surfaces are extremely tough; material provides unusual chemical resistance and anti-frictional properties that make an excellent load-bearing material operating under extremely low or high temperatures. Keys and bushings are fabricated from a material proven to have outstanding abrasion resistance; holds up indefinitely under frictional conditions, thus eliminating need for lubrication.



This V & O Notching Press is powered by a new Sterling "Lube-Free" variable speed drive. It will never need lubrication. Similar units have been installed in the food processing industry. The elimination of lubrication is particularly important in the food processing industry where variable speed drives have such wide application, and where oil and grease create sanitation problems.

Hathaway INSTRUMENTS INC.

Sterling Electric Motors, Inc.

5401 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA,
A Subsidiary of HATHAWAY INSTRUMENTS, INC.

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WITH 2,000 STANDARD UNITS AVAILABLE PUROLATOR HAS THE RIGHT FILTER FOR EVERY FILTRATION APPLICATION

The narrow tolerances and precisely-machined parts found in today's equipment demand proper filtration for maximum output and long life. In fact, filtration has become a basic tool of the product designer. Shown are just four areas in which standard Purolator filters can result in improved design... better performance... reduced wear. Purolator is the world's most experienced manufacturer of filters. Whatever kind of filtration your design calls for, chances are *standard* Purolator filters will do the job. Consult your nearest Purolator office. Or, if yours is a specialized application, we'll design—and build—a filter to fill your needs. Write: Purolator Products, Inc., Rahway, New Jersey.

1. AIR INTAKE FILTRATION.

Purolator dry air filtration positively prevents all contaminates from entering engine. After becoming clogged with dirt, conventional oil bath filters continue to let damaging, dust-laden air into the engine. On the other hand, a dry type filter like a Purolator Micronic® unit positively filters all air entering the

engine. Purolator's new 2-stage filter continues to remove 99.98% of all contaminates even if one filter element should be out of operation.

Replacing a Micronic® filter element is easy too. Takes less than a minute. And since there is no oil to spill . . . no oil level to maintain . . . the filter can be installed anywhere on the engine.

2. LUBRICATING OIL FILTRATION.

Purolator's "selective" filtration leaves additives in heavy-duty or detergent oils. Improper filtering of lubricating oils can also remove costly, engine-protecting additives.

Controlled porosity of the Micronic® element of a Purolator lubricating oil filter removes particles of dirt measured in microns

(.000039-inch). Yet, it never removes needed additives. These Micronic® elements are unaffected by high temperatures or water. Never develop soft spots—or channel.

What's more—a Purolator Micronic® filter of correct size can handle full lubricating oil flow for even the largest engines. This eliminates the need for partial flow systems—whereby many harmful contaminates can remain in the lubricating system.

3. GASOLINE ENGINE FUEL FILTRATION.

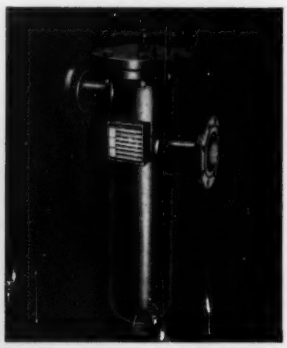
Compact Purolator GF-11 Series fuel filter is adaptable to many gasoline engines. Particles of dirt as small as 10 microns in the fuel system can choke and stall a gasoline engine. Carburetors like the modern 4-barreled units especially need positive filtration for efficient operation.

Purlator's GF-11 Micronic fuel filter is especially designed for the job. Used on many 1961 cars, it can be incorporated equally well into the fuel system of many gasoline engines.

Measuring only 3" x 1¾", it can be easily installed either horizontally or vertically. Fully 70 square inches of filtering surface removes all contaminates down to 5 microns. Filter is designed as a throw-away unit... good for over 5,000 miles of operation.

4. DIESEL FUEL AND LUBE OIL FILTRATION.

Series G-144J metal edge filters offer permanent, uninterrupted filtration for fuel and lube oils. Standard equipment on many of the largest, most modern diesel engines, the G-144J filter requires an absolute minimum of maintenance.



Made of precisely-spaced metal ribbon wound in cylinder form, the filter element lasts indefinitely. Cleans by an occasional twist of the hand wheel on top of the unit which rotates the filter element against a fixed knife blade. No need to cut off the engine or to interrupt the flow of fuel.

Spacing of ribbon determines degree of filtration—which ranges from 25 to 500 microns. Fine filtration is recommended for fuels. Less fine filtration for lube oils.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, CANADA

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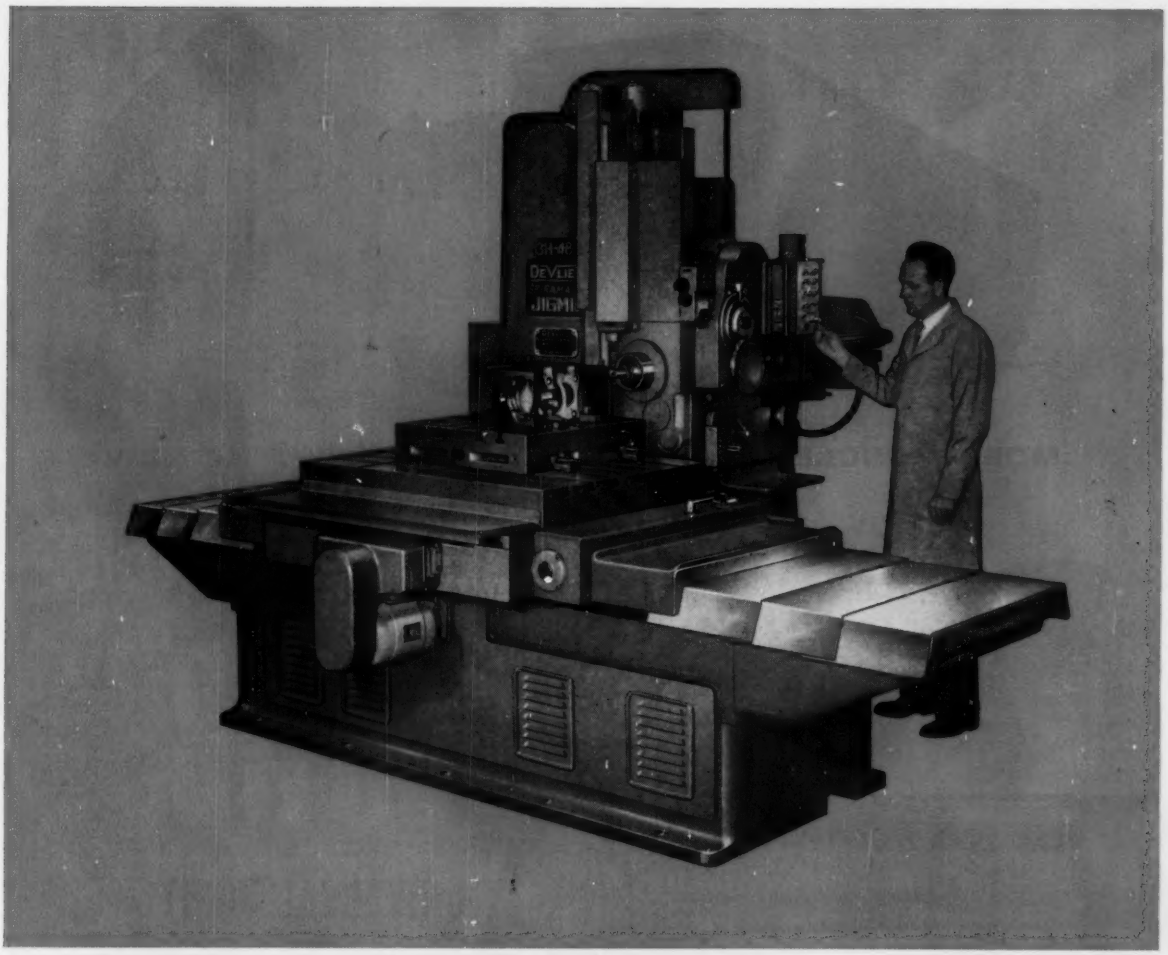

DeVlieg selects Bendix Elmag* clutches for trouble-free operation, flexibility

The Bendix Elmag (electromagnetic) friction and tooth type clutches are simple, compact, and easy to install. They have no external shifting mechanism; deliver greater torque than mechanical clutches of the same size.

"We've standardized on Bendix Elmag multiple disc clutches in the bar feed assemblies of our series 'H' Spiramatic Jigmils® for some very good reasons," says Mr. Richard Jerue, DeVlieg Vice President in Charge of Engineering. "The Elmag has always given us smooth, trouble-free performance. And its simplicity gives us flexibility in locating the control where it will be handiest for the operator. The clutch's compactness also permits easy shielding for added protection." Tape-controlled DeVlieg Jigmils are equipped with a second disc clutch, plus two tooth-type Elmag clutches used on positioning drives.

Because they save space (or provide added torque in the same space), and have less or no idle torque, Bendix Elmag clutches have growing appeal to the design engineer. Give *your* machine designs these performance advantages—write for complete details.

*TRADEMARK

THIS BENDIX ELMAG CLUTCH EKE 4-S-24 is used in DeVlieg Spiramatic Jigmil. Multiple disc clutches are available in torque capacities of 10 to 16,000 ft.-lbs. (Bendix tooth clutches also available from stock—40 to 4,000 ft.-lb. capacities.)

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

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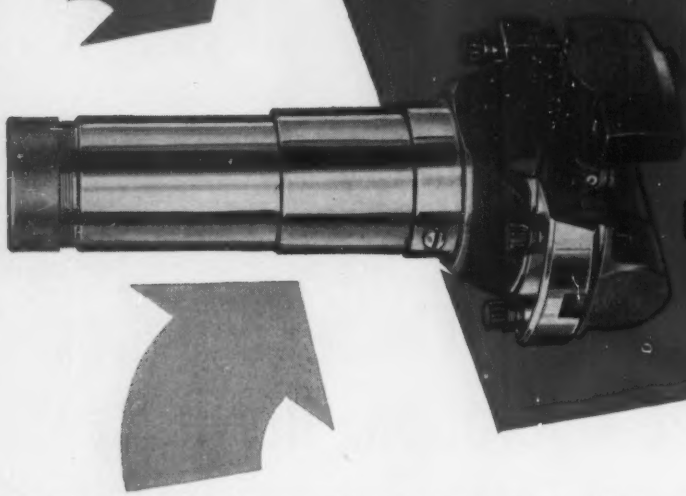
MORE MUSCLE IN A SMALLER PACKAGE... THE NEW

BLOOD BROTHERS "58WB" UNIVERSAL JOINT



To meet new drive line requirements on its 1961 model trucks, a major truck manufacturer needed a special, lightweight but strong universal joint—a unit that would provide greater torque capacity without increasing swing diameter. Rockwell-Standard engineers were consulted, and in a cooperative effort the new "58WB" was developed. It is now being used on several models in the manufacturer's 1961 line.

The design of the new "58WB" is applicable to medium-weight trucks, off-highway equipment, small crawlers and front-end loaders of approximately 1½ yards capacity. It can be made up as a complete drive line, furnished as a component part for a manufacturer's own drive line, or utilized in close-coupled drives. The "58WB" offers these outstanding advantages:

★ **More capacity than any joint of comparable size.** The "58WB" provides 39,000 inch pounds torque capacity with a swing diameter of only six inches!

★ **Key-type yoke.** Requires only four bolts for installation on original equipment. Saves downtime for repairs.

For more details about the new "58WB" or for help in solving any problems involving universal joints or drive lines, write or call us today.

Another Product of...

ROCKWELL-STANDARD
CORPORATION

ROCKWELL R STANDARD

Universal Joint Division, Allegan, Michigan

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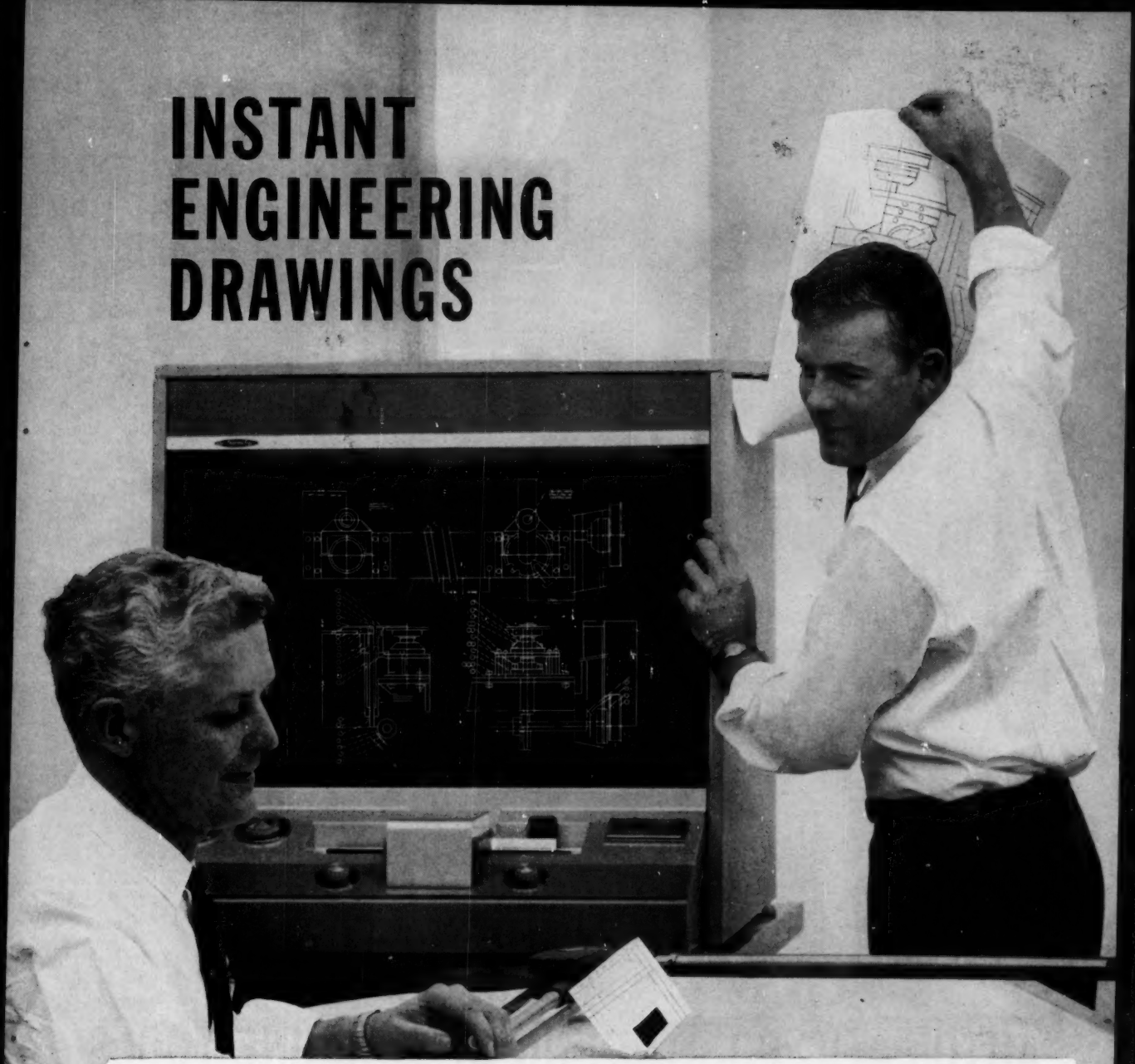
INSTANT ENGINEERING DRAWINGS



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3M MICROFILM
BRAND PRODUCTS

3M Company Dept. FBO-8171, St. Paul 6, Minn.

Please send me information about Instant Engineering Drawings.

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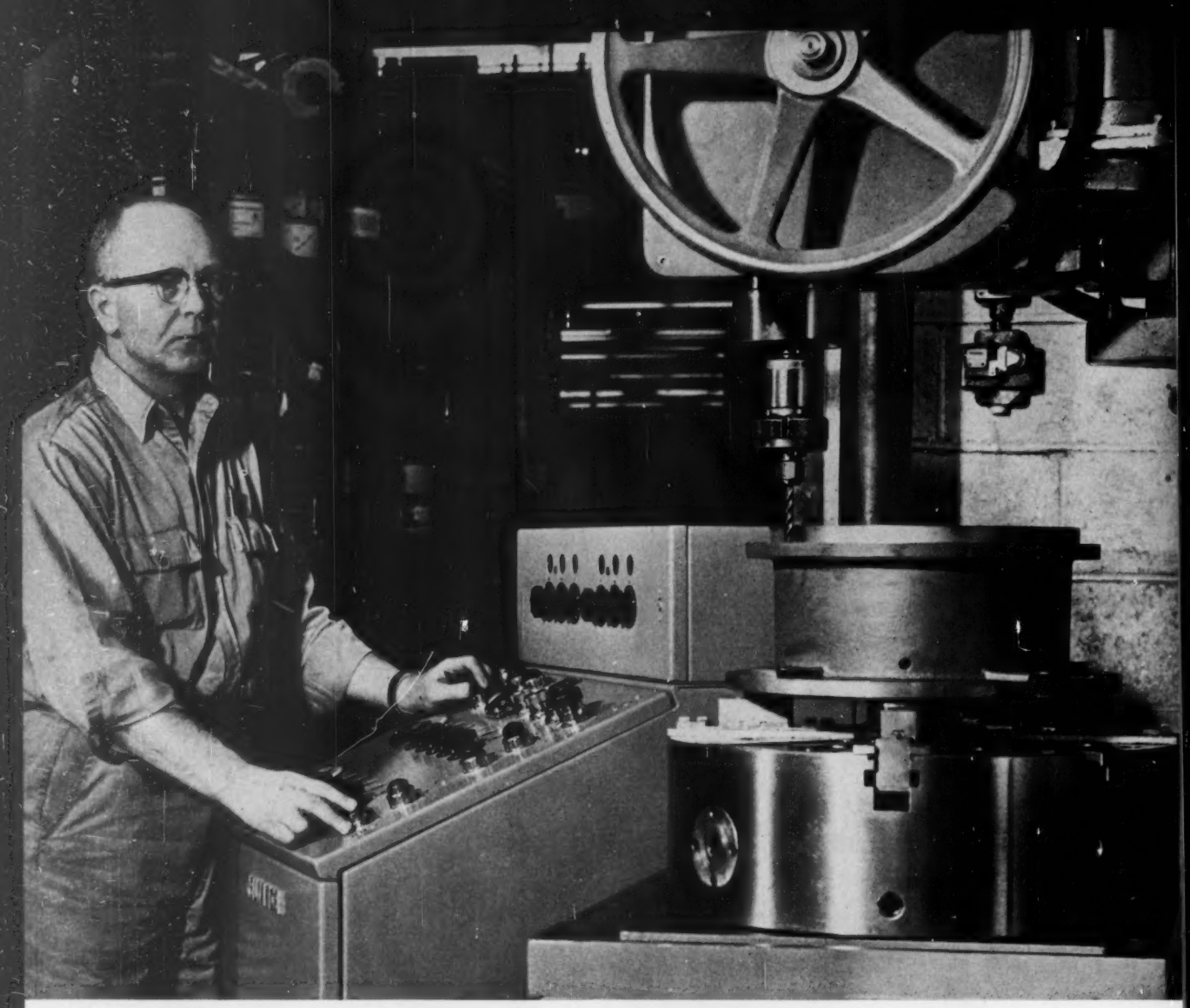
THE TERMS "FILMSORT" AND "THERMO-FAX" ARE REGISTERED TRADEMARKS OF

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW



NEW RELIANCE SYSTEM FOR AUTOMATIC POSITIONING OF MACHINE TOOLS

This drilling machine is operated by Reliance Programmed Numerical Control. It cuts the costs of lead time and expensive tooling. It provides fast, highly accurate positioning . . . electrical accuracy of ± .0001 inch and repeatability of .00001 inch can be achieved. This is an absolute system operating from a fixed reference with no cumulative error.

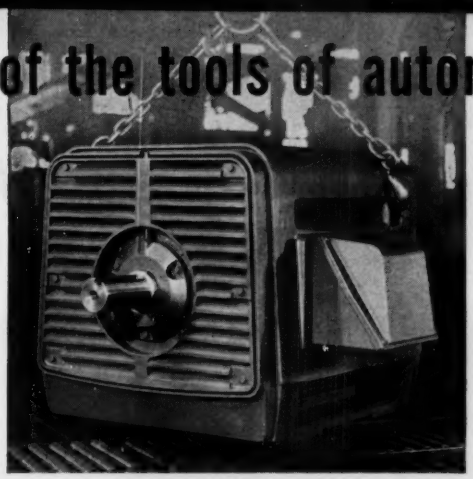
The Reliance drive operates feed motors at high speed until position is approached. Motors are then slowed down in proportion to the distance from the programmed point, stopping at the exact position. Any number of linear or rotary motions can be controlled simultaneously or individually for complete automatic operation. Provision is also made for programming auxiliary functions, such as turret selection, clamping and coolant control.

Reliance Programmed Numerical Control uses 8-channel machine tape or dial selector switches for input. Operates from standard tape processing and reading equipment.

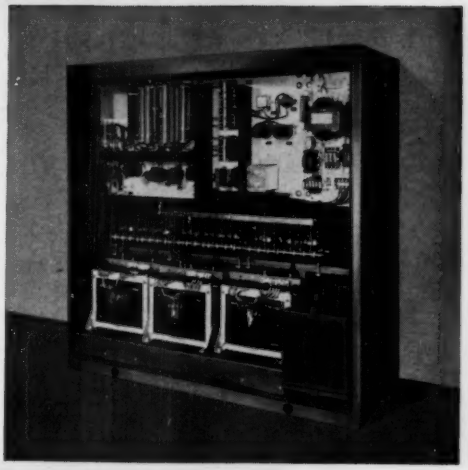
It will pay you to get the complete facts about this equipment. Your Reliance Sales Engineer has all the information. Consult the Yellow Pages or write us direct.

A-1686

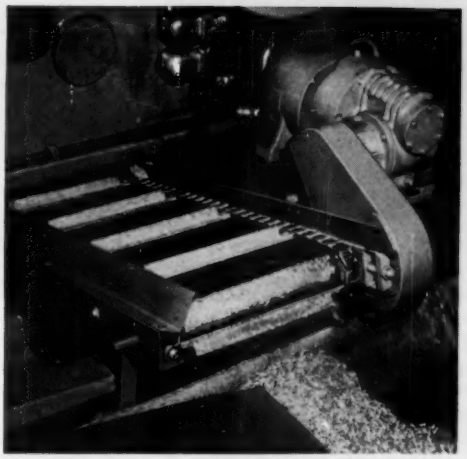
RELIANCE...builders of the tools of automation



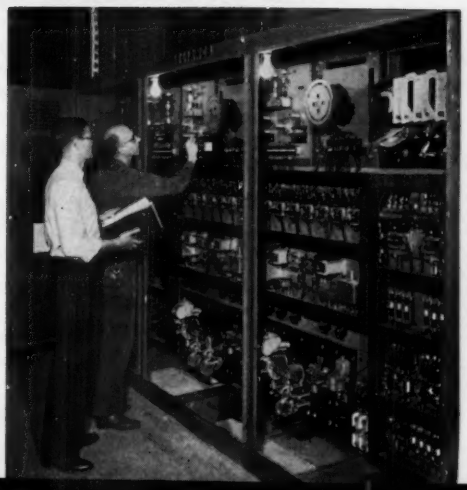
NEW DUTY MASTER D-5000 design brings you new standards in coolness, quietness . . . and more horsepower in less space. Frame dimensions that held 150 hp. now contain 300 hp. There is better heat dissipation from the frame itself. Air flows easily through the entire grilled end areas—exhausts through long, protected slots at the sides and bottom. New fingerless ducted rotor design means better cooling than any other previous motor. You get all famous Duty Master features in this new D-5000 . . . special lubrication design, drip or splash-proof and complete open motor protection. Bulletin B-2515.



RELIANCE V★S STATATRON is a static powered drive for wide range variable speed from in-plant a-c. circuits, available from 1 to 200 hp. Instead of a motor-generator set, the Statatron uses silicon diodes and saturable reactors to rectify the current from a-c. to d-c. These work in combination with a transistorized power exciter to supply variable voltage. Statatron is compact—35% smaller than conventional units. Consists of only three components: Super 'T' d-c. motor, operator's station and control cabinet. Statatron is quiet—vibrationless and low in maintenance cost. Bulletin D-2508.



THIS MASTER GEARMOTOR drives a chip conveyor on an automatic screw machine. The combination parallel and right angle reduction produces efficient low output speed at high torque —ideally suited to this operation. Features important here are its compactness and one piece construction, saving space and maintenance. This Master Gearmotor is impervious to liquids . . . splashing of coolant and any other outside contamination. Where the situation calls for gearmotors, this full line can cut your engineering and assembly costs . . . give you dependable performance. Bulletin E-2409.



TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

RELIANCE ELECTRIC AND ENGINEERING CO.

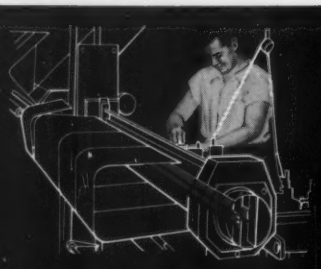
DEPT. 28-8, CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.

Circle 292 on Page 19

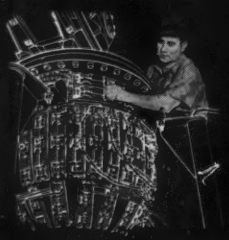
CHROMALOX ELECTRIC STRIP HEATERS

Versatile, dependable, uniform heat for your product or processing needs

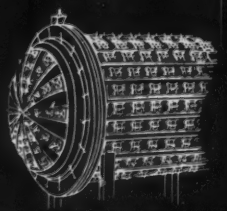
Chromalox Strip Heaters, sheathed in iron, chrome steel and Monel, come in sizes and types for every need. 4" to 96" lengths; 1" to 2½" widths. Also available in full rings and segments.



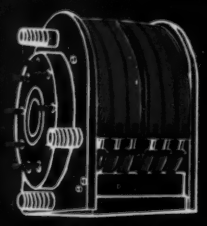
Rolls for bending plywood to form luggage case bodies are uniformly heated with long Chromalox Strip Heaters.



Zoned heat and close temperature control is obtained in grease kettle with separate groups of Strip Heaters.

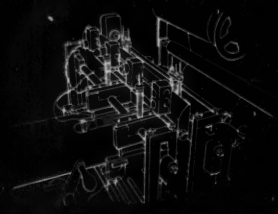


Vacuum dehydrating oven, also used as vacuum furnace at temperatures to 950° F., equipped with Type SE Strip Heaters and SR segment heaters.



Aluminum extrusion container heated by curved Strip Heaters around circumference and Chromalox Cartridge Heaters in holes closer to billet.

Brake-lining bonding oven equipped with three SE Strip Heaters and a Ring Heater to produce uniform bond.

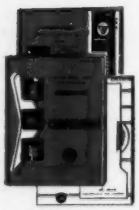


Sealing arm on platen with thermostatically controlled Strip Heaters on each side delivers constant temperatures regardless of machine speed.

Compact, metal-sheathed Chromalox Strip Heaters assure accurate temperatures, dependable around-the-clock service anywhere heat is needed for product or process. It is by far the most versatile built-in heat source available today. Easy to install—Chromalox Strip Heaters produce uniform and accurate temperatures with automatic or manual controls.

Low initial cost, low installation costs and low operating costs are among the many other advantages of using Chromalox Strip Heaters for heating tanks, platens, ovens, molds, moving parts, and similar uses. Over 500 standard sizes, shapes, ratings and terminal arrangements available immediately from stock. Get the full details now.

GET THE FACTS
Write for Industrial Processing Catalog 60, Comfort Heating Catalog F-975D, Infrared Catalog G-62.



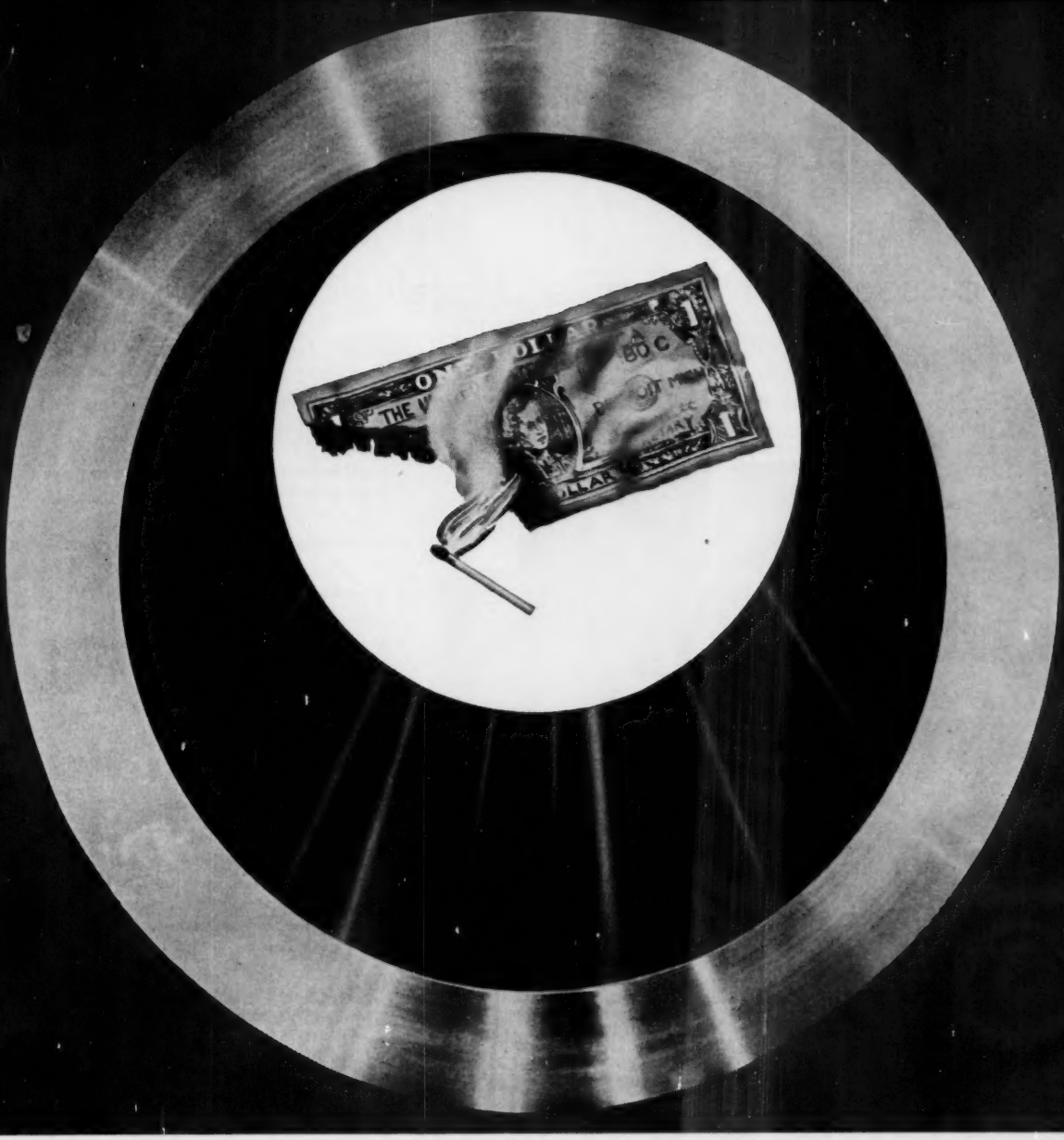
WI-10

EDWIN L. WIEGAND COMPANY
7575 THOMAS BLVD., PITTSBURGH 8, PA.

CHROMALOX
ELECTRIC HEAT

PROCESS | COMFORT

Circle 293 on Page 19



WHY PAY FOR METAL WASTE?

Here is how to cut costs on your next tube order... by eliminating excessive metal waste and unnecessary machining time.

NOW FOR THE FIRST TIME you can order the exact size tube O.D.'s you need from 2.25" to 50" with wall thicknesses from .25" to 8". An exclusive "first" in centrifugally spun tubing — the ACIPCO CERAM-SPUN® process* makes this revolutionary development possible.

YOU BUY WHAT YOU NEED... NO MORE. Furthermore, the cost of unwanted crop ends can be eliminated and tubes can be cast to specified lengths from 4 feet to 20 feet. Longer lengths are made by welding.

OTHER ADVANTAGES? ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — save you the delays and excessive costs that often result in buying from multiple supply sources.

Let us tell you more about ACIPCO CERAM-SPUN® ...contact us today. ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

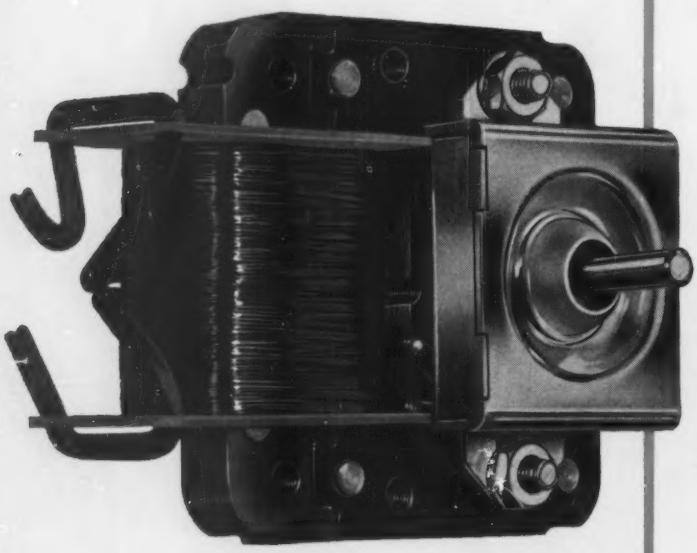
*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

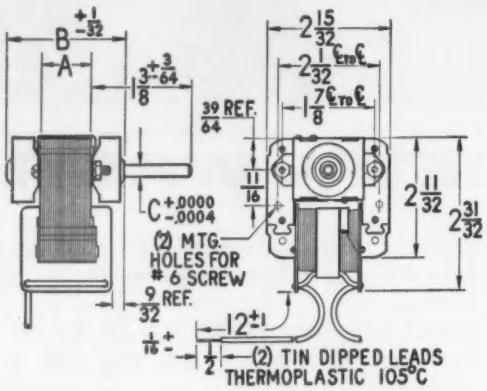
Circle 294 on Page 19

NEW TYPE EA1 UNIVERSAL SKELETON MOTOR

a superior unit because of quality construction, larger bearings and greater oil capacity



- **Larger bearings and greater oil-felt capacity give longer motor life.**
- **Grooved bearings insure continuous oil return.**
- **Larger bearings reduce motor noise.**
- **Accurate metallurgical control of laminations insure uniform performance.**
- **Interchangeable mountings.**
- **Six standardized models, 1/500 to 1/45 HP.**
- **The correct motor for rotisseries, vending machines, office machines, chart drives, phonographs, slide projectors, heaters, refrigerators, hair dryers, deodorizers, 2" to 8" diameter fan blades, electronic equipment, etc. Write for complete specifications on your requirements.**



SPECIFICATIONS

UNIVERSAL TYPE EA1 SKELETON MOTORS 115 VOLT 60 CYCLE

MODEL	HP @ 2,800 RPM	MAXIMUM TORQUE oz. in.	DIMENSIONS		
			A	B	C
EA1A	1/500	1.1	3/8"	1 53/64"	.1817
EA1B	1/350	1.4	1/2"	1 41/64"	.1817
EA1D	1/130	3.3	3/4"	2 3/16"	.1817
EA1E	1/90	4.5	1"	2 7/16"	.1817
EA1G	1/60	6.5	1 1/2"	2 15/16"	.250
EA1J	1/45	7.5	2"	3 7/16"	.250

12" leads on all models

57

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

They make piston pins faster for less money with USS National Seamless Mechanical Tubing

It takes plenty of machine time to drill and machine the holes in 6,500,000 piston pins a year. That's what one major auto company* had to do . . . *until* the switch to USS National Seamless Steel Mechanical Tubing. By eliminating the need to drill holes in the bar stock, the company got rid of six chuckers formerly used for drilling, saved time as well as the power they consumed and the space they occupied. ☐ USS National Seamless Tubing has dimensional accuracy. It has no hard or soft spots. It's made by people who know more about seamless tubing than any other manufacturer in the world. You can choose from a complete range of sizes and steel grades. Find out how USS National Seamless Mechanical Tubing can be most effectively applied to your designs. Contact your nearest National Tube Distributor soon.

USS and National are registered trademarks

**Name supplied on request*

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

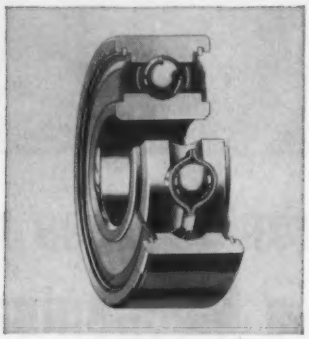
This mark tells you a product is made of modern, dependable Steel.

Circle 296 on Page 19

A NEW PRODUCT DEVELOPMENT FROM BARDEN

TO KEEP YOUR BRAINCHILD SPANKING CLEAN

A spaceman's helmet can keep a boy's face clean for a while, but the protection is far from permanent. A new Barden development, however—Flexeal—positively seals precision bearings against dirt while retaining needed lubricant, thus greatly increasing the reliability of high-speed motors, generators, computer memory drums and other equipment.



Sectional views of Flexeal precision bearing show how fiber-aluminum laminate seals against ground surface of inner ring to effectively block out dirt and retain bearing lubricant.

SEALED PRECISION BEARINGS

Barden's new Flexeal meets the demand for a low-friction seal that can stand up at high speeds in contaminated environments. Flexeal bearings are precision bearings with a seal of fiber-aluminum laminate that fits smoothly against a ground surface on the inner ring. The design effectively seals in lubricant, seals out contaminants and prevents airflow through the bearing. Friction is negligible and the bearing may be run up to the life limit imposed by the lubricant.

TEST RESULTS

Barden Flexeal bearings have been operated up to 3,000 hours at 80,000 rpm in portable grinders. Flexeal stands up under lineal speeds of 6,000 feet per minute, as against 2,000 to 3,000 fpm limits of most other rubbing seals. Operating temperatures range up to 300°F.

AVAILABLE NOW

Flexeal bearings are now available in ten unflanged and four flanged sizes from .3125″ to 1.8504″ O.D. For further data, ask for Flexeal Data Sheet F-1.

Barden is a major producer of precision ball bearings for instruments, weapon systems, computers and other high quality equipment.

for reliability...specify

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 208 Park Ave., Danbury, Conn. Pioneer 3-9201
Western Office: 3850 Wilshire Blvd., Los Angeles 5, Calif. DUnkirk 5-0034

ASARCON

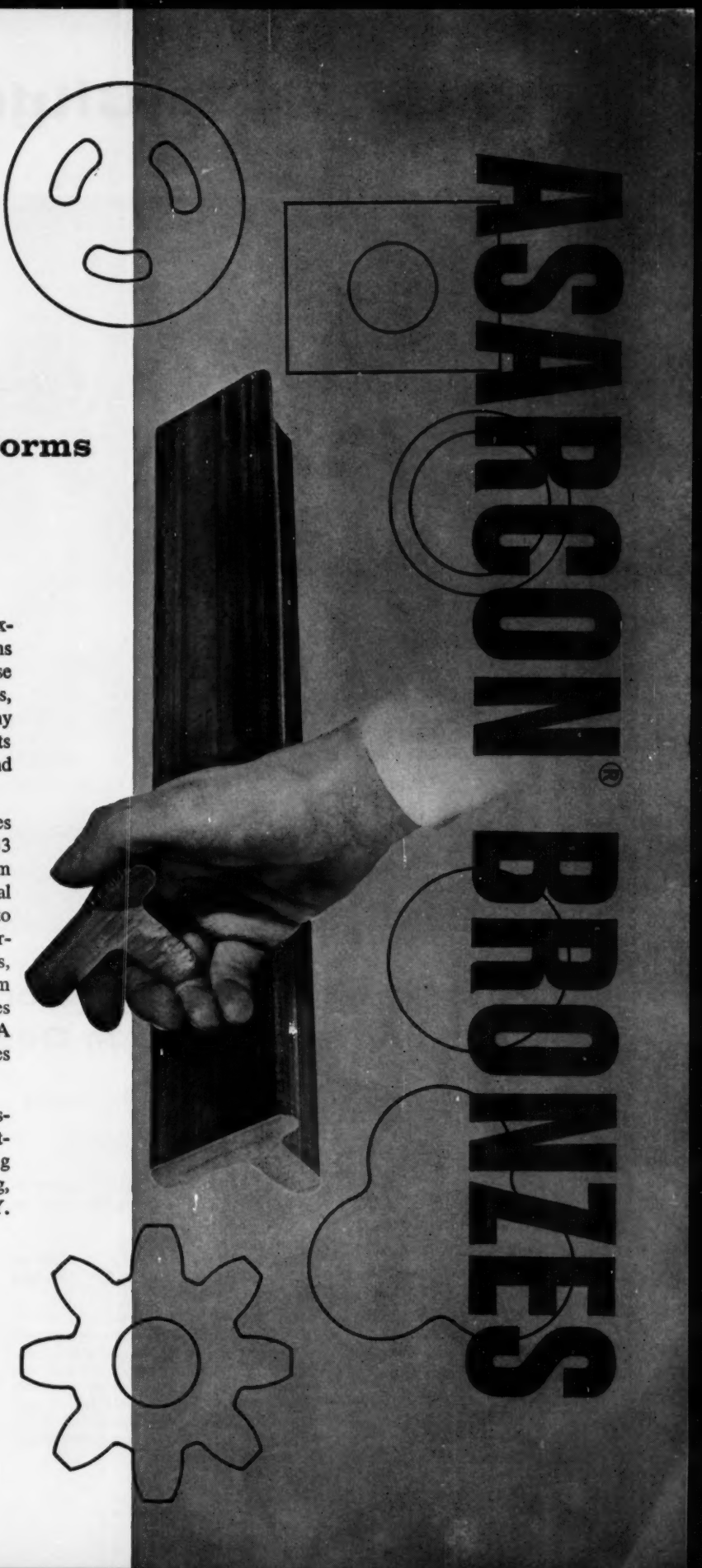
custom shapes and forms in any lengths you need

Asarcon continuous castings give you an extremely wide variety of shapes and forms in standard bronze alloys. They will increase your production rates and lower your costs, because: you get the shape you want in any length you need up to 20 feet. This permits machining on automatic screw machines and other high-speed equipment.

Continuous casting of Asarcon bronzes raises fatigue characteristics of standard alloys 33 to 100%, increases impact strength from 15% to more than double that of identical alloys cast other ways, adds materially to tensile, yield strengths and hardness. Asarcon 773 (SAE 660) bearing bronze in solids, rods and tubes is immediately available from stock in your choice of more than 260 sizes up to 9" O.D. and lengths up to 105". A wide variety of other special alloys, shapes and sizes produced to order.

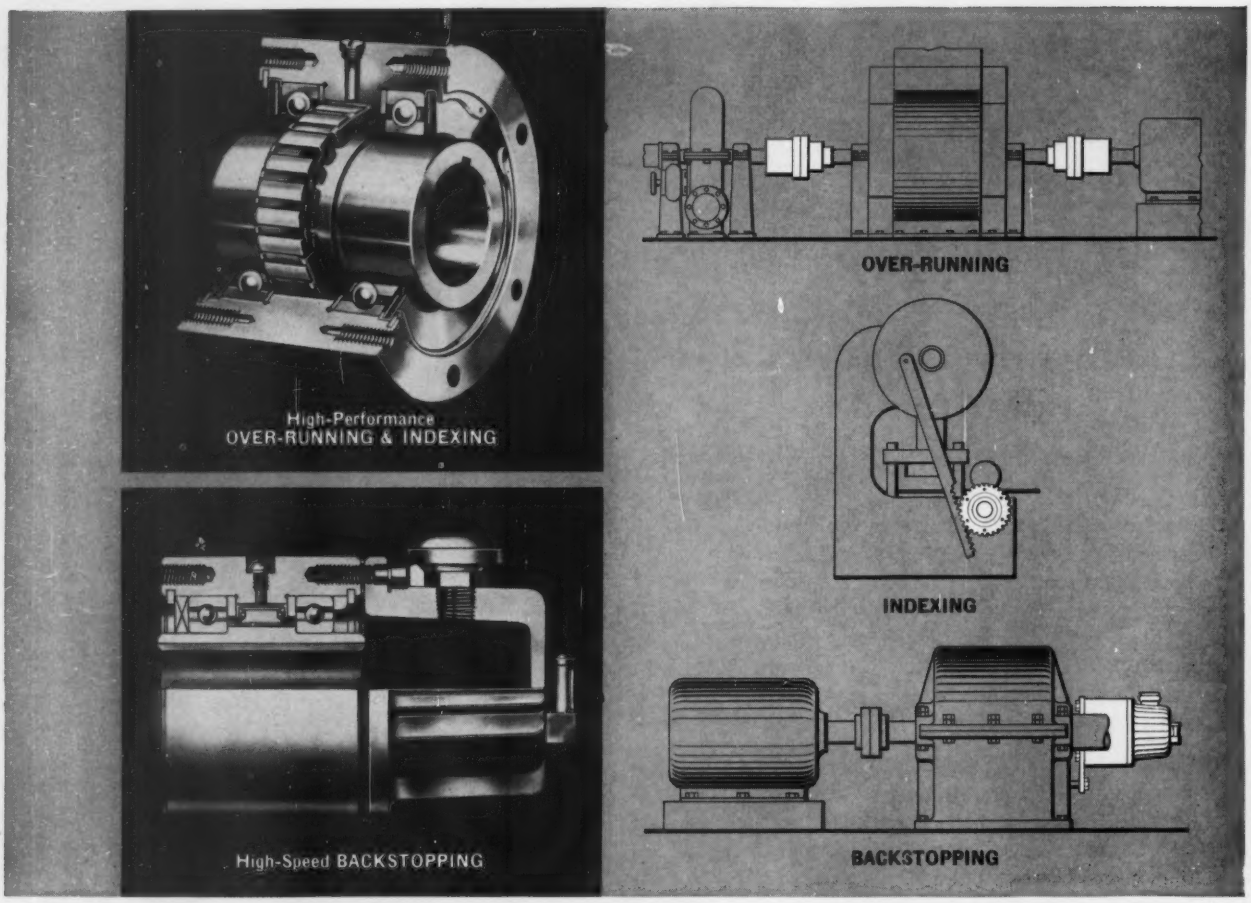
For complete data on Asarcon continuous-cast bronze, write Continuous-Cast Department, American Smelting and Refining Company, Perth Amboy, N. J., Whiting, Ind.; or 120 Broadway, New York 5, N. Y.

ASARCO



Circle 298 on Page 19

FORMSPRAG Clutches have



These Installations Prove Formsprag Has The Most Advanced Clutch Designs Available

On tough applications requiring high-performance over-running, indexing or backstopping, Formsprag clutches have *proved* their unusual durability, precision and reliability. Their long-life and minimum maintenance requirements, even under unusually demanding installation conditions, have provided many users with the answer to their clutch problems. Compare the following performance results on actual installations—Formsprag designs can help you, too!

High-Performance Over-Running

Application:
Forced and Induced Draft Fans.

Clutch and Mounting:
Model FO-732 Clutch-coupling (HPO-720 clutch with coupling) mounted on fan drives.

Requirements:
Continuous over-running at 1200 to 1800 R.P.M. (24 hours a day, 365 days a year).

Proved Results:
The Formsprag HPO clutch design with Formchrome sprags provides this company with greater durability and less maintenance than any other available clutch. Therefore, on all forced and induced draft fans, this manufacturer specifies Formsprag high-performance over-running clutches.

Precision Indexing

Application:
High Speed Press.

Clutch and Mounting:
Model HPI-700 feeding a progressive die.

Requirements:
20° indexing; feed is 700 strokes per minute; accuracy of feed must be within .005"; press operates 24 hours a day, 5 days a week.

Proved Results:
After poor service life and unreliable results from other clutch designs, a Formsprag high-performance indexing clutch was installed. Result—customers requirements for accuracy were met, clutch has had a life of 80 million cycles and is still running.

proved higher performance

(GREATER TORQUE & SPEED, HIGHER PRECISION, LONGER LIFE)

During the last two years, Formsprag has announced several major advances in over-running clutch design. These advanced concepts have been widely accepted by designers of modern power transmission systems. The high performance results they obtained on over-running, indexing and backstopping applications *prove* Formsprag clutches to have the most advanced designs available.

On-the-job records *prove* these high performance characteristics: (1) Formchrome sprags, with high-hardness and wear resistance, provide exceptional durability—no other manufacturer can offer the performance advantages of Formchrome sprags. (2) The improved sprag and retainer design of Formsprag High-Performance Over-running (HPO) and Indexing (HPI) clutches permit up to 30% higher operating speeds with same life span and up to 70% longer clutch life when operated at same RPM as ordinary clutches. (3) On backstopping applications, the High-Speed Backstopping (HSB) clutch design permits higher speeds, assures longer life and reduces maintenance to a minimum.

Specific case-history data on *proved* over-running, indexing and backstopping installations is provided below. In every instance, users of Formsprag High-Performance Clutches have found the answers to problems of wear, high-speed operation, precision and maintenance.

There is a Formsprag Clutch for every application. Standard models include: sleeve bearing, ball bearing, miniature, large-bore holdbacks, and high-performance types. For special applications, Formsprag engineers will recommend a modified standard clutch or design a special. Standard clutches are fully described in the Formsprag catalog—send for your free copy.

FORMSPRAG COMPANY

23603 Hoover Road, Dept. 114-A — Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

High-Speed Backstopping

Application:
Iron Mining (Taconite) Conveyor.

Clutch and Mounting:
Model HSB-700 clutch assembly mounted on high-speed shaft of reducer.

Requirements:
In abrasive atmosphere, clutch must over-run at 1200 to 1800 R.P.M. (24 hours a day, 9 months of year).

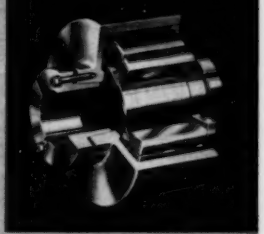
Proved Results:
On this rugged backstopping application, Formsprag HSB clutches solved problems of overheating, premature seal wear, and short clutch life. These high-speed backstopping clutches have been in operation for over a year and are still delivering their initial high performance.

OTHER FORMSPRAG PRECISION PRODUCTS

NEW RAWSON

CENTRIFUGAL CLUTCHES and CLUTCH-COUPLINGS

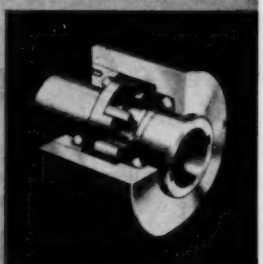
Used in a wide variety of applications, the Rawson design provides no-load starts for motors and cushioned starting of driven equipment. They permit using smaller motors and across-the-line starting.



REVLOK

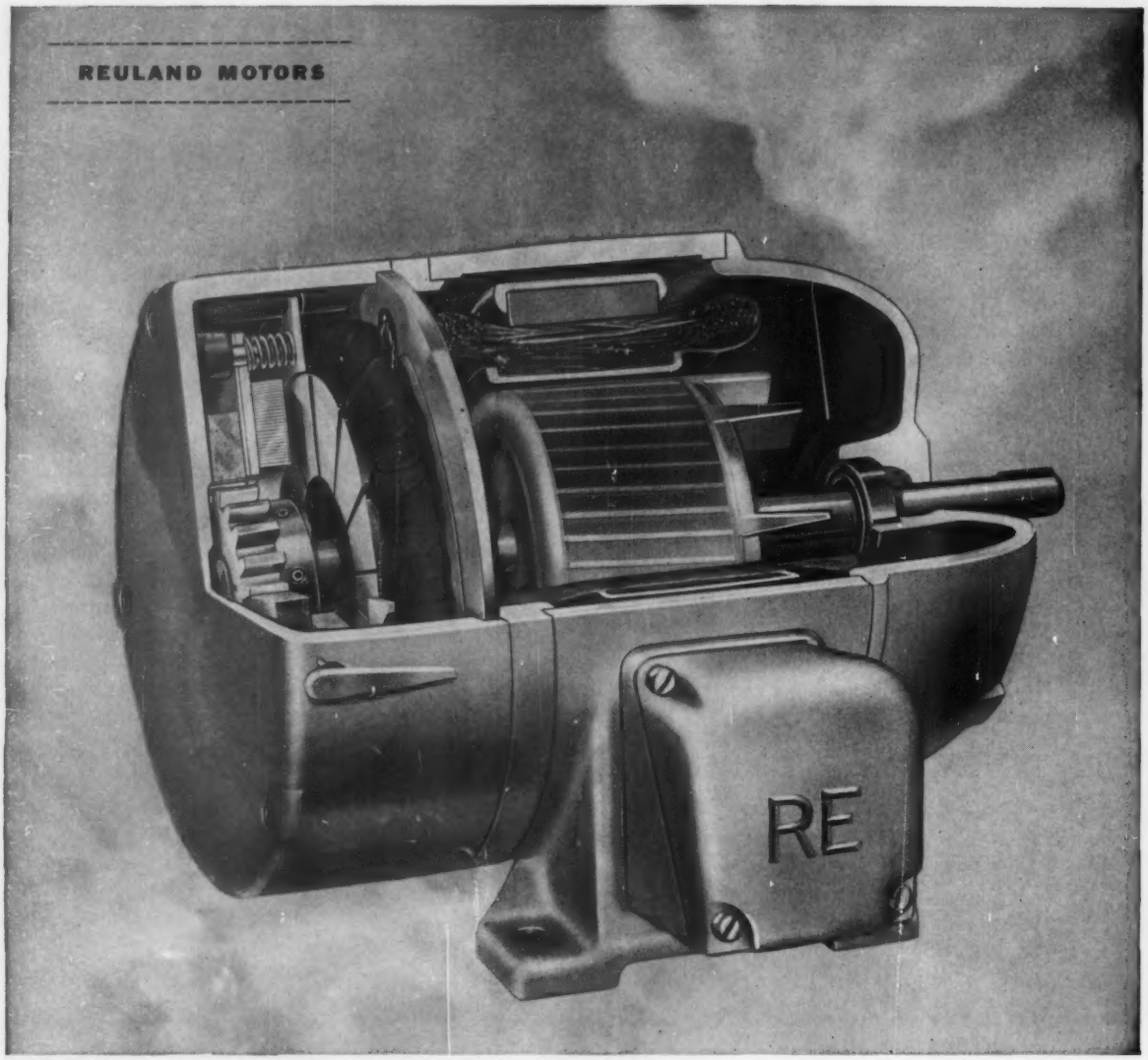
DUAL TORQUE-LOCKING and POSITIONING DEVICES

These multi-purpose devices stop feedback torque and provide two-directional positioning, over-running, backstopping and load-limiting. They can also be adapted for single revolution and torque-limiting functions.



Circle 299 on Page 19

REULAND MOTORS



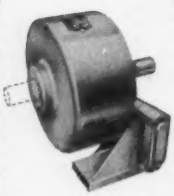
Reuland motor-and-magnetic-brake package

...complete from one dependable source!

Reuland manufactures its own magnetic brakes, as well as electric motors, and offers the most versatile selection of tailored-to-your-equipment *brakemotor* packages available anywhere. Reuland's many hundreds of combinations of H.P., speed, special drive motors and brake sizes, provide an almost unlimited coverage of O.E.M. and user requirements!

So, whatever your *brakemotor* needs may be, standard or special, let Reuland supply the complete answer in one, compact, smartly-designed power package. One source of supply for brake and motor saves time for your Engineering and Purchasing Departments... one nameplate establishes dependable, nationwide service responsibility!

Refer to Sweet's 1961 Product Design, Section 7a/RE



BRAKES AVAILABLE IN ALL 3 MOUNTINGS... FULFILLS J.I.C. SPECIFICATIONS!

1. Direct endbell type for mounting over motor's shaft.
2. Foot mounted, for mounting over existing shaft.
3. Foot mounted—complete with own bearings and shaft.

- Automatic Lining Wear Adjustment
- Manual Release—Automatic Reset
- Mount in any position
- No Levers or Linkage
- One-Piece Housing
- One-Half Conventional Length
- Wide Range of Ratings

Our new 8-page catalog, No. GS8-30-0, will come in handy. Sent complete with prices and engineering drawings on request.

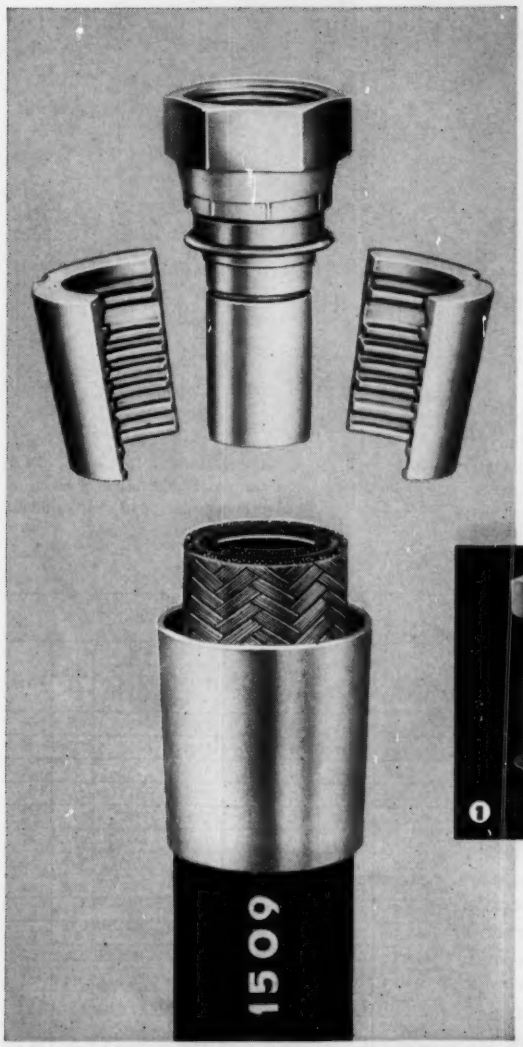
MODERN POWER FOR MODERN-DAY PRODUCTS

...all in lightweight, cool-running aluminum frames!

REULAND MOTORS

REULAND ELECTRIC COMPANY
WESTERN DIVISION: *Alhambra, Calif.*
EASTERN DIVISION: *Howell, Mich.*
Distributors in all principal cities

NEW IRON MIKE T.M.

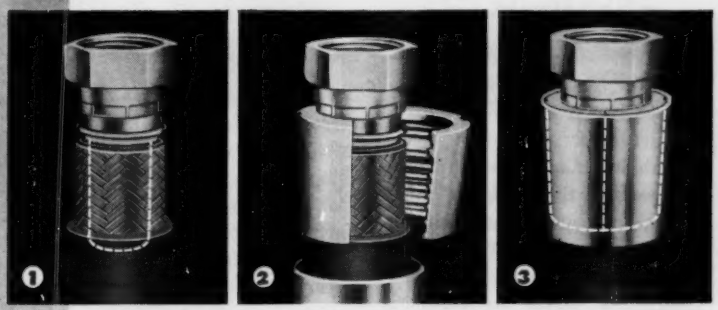


REUSABILITY PLUS LOW COST MAKE IT THE MOST IMPORTANT NEW HIGH PRESSURE HOSE FITTING IN YEARS

Aeroquip scores a major breakthrough in the cost of high pressure hose lines. IRON MIKE Fittings are completely reusable! IRON MIKE Fittings are exceptionally low cost! They give you the design, prototype, manufacturing and field service advantages provided by hose lines with standard reusable fittings . . . at the low cost of hose lines with non-reusable fittings.

Use IRON MIKE Fittings with Aeroquip Multiple Wire Braid Hose for hydraulic systems up to 2250 psi. as well as for pneumatic, fuel and lubrication lines. IRON MIKE Fittings are available with 10 standard end styles for hose sizes from ¾" to 2" I.D.

Field tested and thoroughly dependable, IRON MIKE Fittings feature quick, easy, foolproof assembly. Get complete information by returning the coupon below.



IRON MIKE Fittings consist of a steel nipple, two aluminum segments, and a tapered steel socket. Assembly of IRON MIKE Fittings and 1509 Hose is simple and sure: **1.** Rubber Cover is stripped from hose end and threadless nipple is inserted into hose. **2.** Two segments mate with nipple assembly to assure correct positioning. **3.** Tapered socket is forced over segments to form a rugged compression fitting.

PATENT APPLIED FOR

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN PLANT, BURBANK, CALIFORNIA • AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO AEROQUIP G.m.b.H., BADEN-BADEN/FOS, GERMANY AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Aeroquip Corporation, Jackson, Michigan

MD-8

Please send me Bulletin 651 on new IRON MIKE Fittings.

Name_____

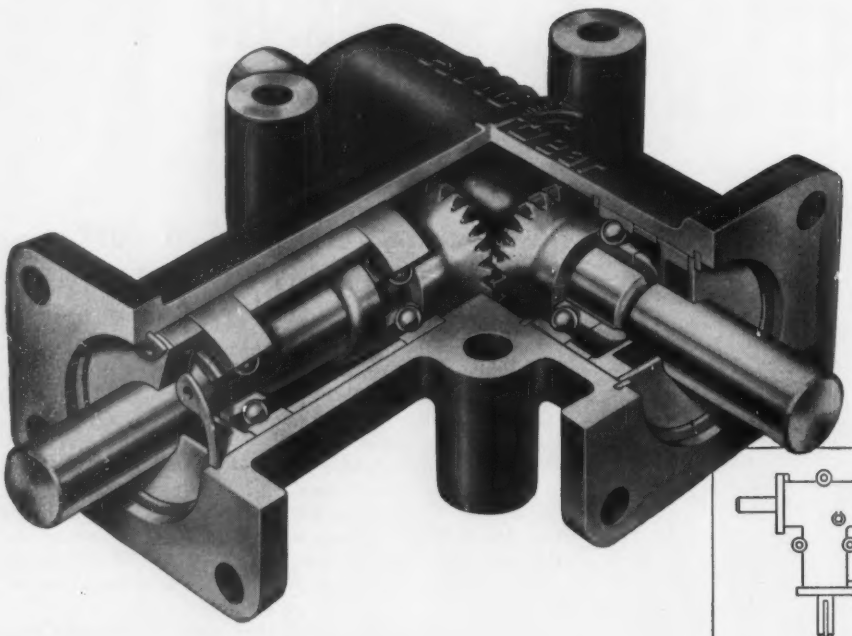
Title_____

Company_____

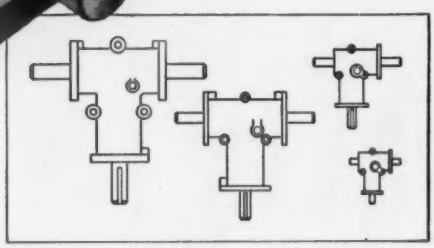
Address_____

City_____ Zone____ State_____

There is only one ANGLgear®... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range (½ to 5); permanent lubrication; and Coniflex* design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear—introduced in 1951—is the *original* standardized right-angle drive. It is also the No. 1 product in its field — in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date — for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it—for years. And attention is seldom required.

Besides being maintenance-free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. *ENGINEERS: Write for free ANGLgear design templates.*

*Trademark of the Gleason Works

BASIC MODEL DATA

Model	Type	Gear Ratio	HP	RPM Output Shaft	Ultimate Static Torque lb. in. Output Shaft	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15

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AIRBORNE ACCESSORIES CORPORATION

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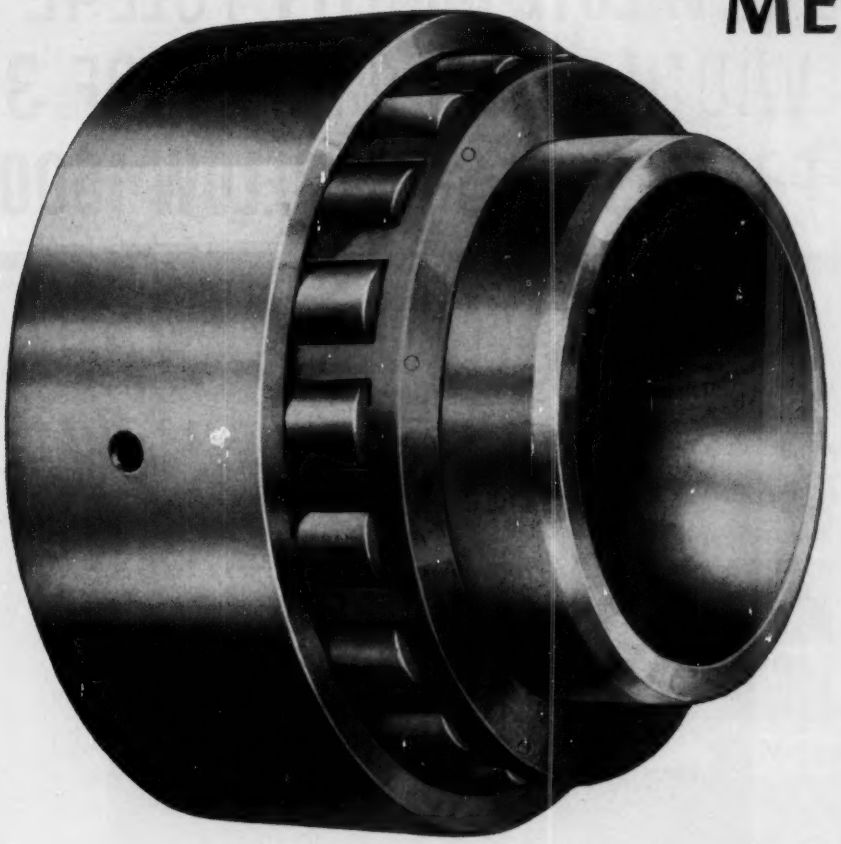
Rugged IS THE WORD... *for* RADIAL ROLLER BEARINGS *by* MESSINGER



TYPICAL APPLICATIONS

Straightener Rolls; Back-up Rolls; Press Rolls; Work Rolls; Drive Shafts of all kinds; Beaters; Embossers; Rudder Shafts; Heavy-duty Cranes.

The list at right is merely indicative of the wide range of applications for these *quality* bearings . . . developed by Messinger to assure long service with enduring accuracy. Made from Messinger special analysis bearing steel, through-hardened in the Messinger heat treating plant. The rugged bronze cages contribute importantly to the long life and efficiency of these reliable bearings, particularly at high speeds.

Messinger Radial Roller Bearings are available in the following standard types and combinations: Plain; Self-Aligning With Adapter; Self-Aligning Without Adapter; Combination Radial and Thrust Bearing; Combination Radial and "X" Bearing. All are designed to carry extremely heavy loads with less space and weight. Standard sizes range from 4" I.D. to 60" I.D. Special types and sizes can readily be designed.

Radial Roller Bearings are just one of many types of bearings developed by Messinger to provide new measures of precision, compactness and long life. Engineering consultation invited, without obligation.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

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"Smoothing Industry's Pathway for Nearly Half a Century"

Circle 303 on Page 19

HERE IS THE **NEW** REVOLUTE **ROCKETTE** THIS **VERSATILE** WHITEPRINTER BRINGS YOU FAMED **REVOLUTE QUALITY**, FULL 42" PRINTING WIDTH, YOUR CHOICE OF **3 MODELS**-AT PRICES THAT START **BELOW $1600**

here's good news

for the company or department that "couldn't afford" a big-production whiteprint machine. You can now! These new Rockettes start below $1600. Yet look what they offer—*compare* what they offer with any other whiteprinter made:

- Full 42″ printing width.
- Your choice of wattages and printing speeds: 30, 40, or 60 watts...15, 25, or 35 fpm.
- Revolute's exclusive perforated roller developing unit. Shortens print travel, saves ammonia. Assures fast print return, uniform print quality.
- Automatic developer control. The Rockette has an automatic pump as standard equipment.
- Table-top or floor stand model, as you prefer.

If you know Revolute, you know it stands for the very best. Yet here is this new Revolute Rockette, priced with the very lowest! For the full story of specifications and costs—simply mail the coupon.

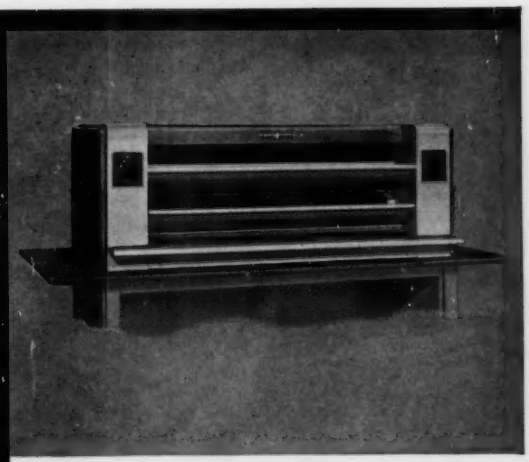
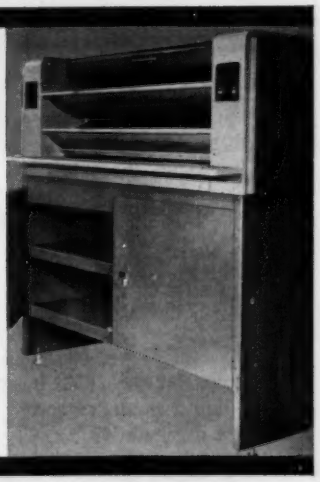
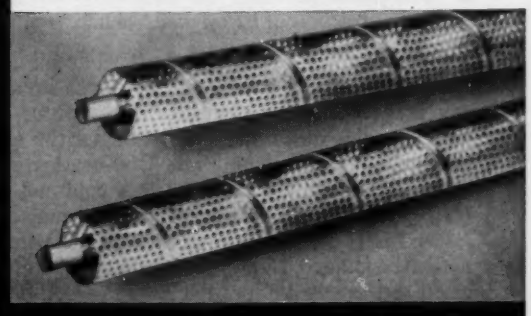


TABLE-TOP ROCKETTE has all the performance features of the floor stand model: three printing speeds, each with automatic developer control.

ROCKETTE FLOOR STAND provides deep, roomy storage area for sensitized, material supplies.



PERFORATED ROLLER DEVELOPING UNIT ...a Revolute exclusive...assures uniform print quality, fast print return.



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How wood engineering helps this ship do the work of a fleet

THIS SHIP — the METHANE PIONEER — is the only one in the world that has ever transported a cargo of liquid methane across the ocean — and she's done it regularly.

It would take 600 ships like this one to transport a load of liquid methane in its natural, gaseous form! By bringing its temperature down to –258°F. at atmospheric pressure, the methane is liquefied to a small fraction of its original volume.

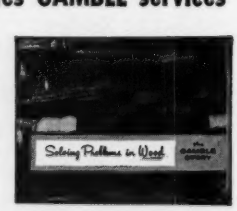
How does *wood engineering* enter into all this? Because wood is a good insulator whose strength increases as temperature decreases. Its properties make possible an insulating system (for the storage tanks) that is liquid-tight, load-bearing, and retains its integrity despite extreme cold and the rack of the ship. Gamble Brothers wood engineers assisted their client, Constock (now Conch) International Methane, Ltd., in the design—then fabricated and installed a foot-thick, balsa-wood-panel insulating system that has met all requirements.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.



If the problem involves wood, Gamble can help!

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GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

MACHINE DESIGN
August 17, 1961

Interservice Rivalry

WANT to start an argument? Just assert, in appropriate company, that engineering is more important than sales—or vice versa—and watch the fur fly.

Of course, such an argument is academic—but fun while it lasts. Sales can say, "We bring in the income that supports engineering, as well as the rest of the company. Without us you're all dead."

Engineering can simply point to the obvious fact that without the product which engineering has designed, sales would have nothing to sell.

Indeed, in the history of most companies that have grown out of a clever engineer's inventions, the sales department has been initially an adjunct, a supporting function to the main stream of company activity.

As competition grows, so grows the need for a powerful sales organization. Thus sales becomes the vital link between the design engineers and the customers for whom the product is designed.

To the design engineer, as George Lennox suggests, the salesman represents the customer. If he is to sell the product successfully, the salesman himself must be sold—by the engineer.

To the customer, the salesman represents the design engineer. He must discuss with authority the engineering features of the product. Equally important, he must listen to, and feed back to the engineer, the customer's views on engineering features.

Sales can, in fact, serve as a sort of intelligence agency for engineering—its eyes and ears out in the field, on the firing line. If sales does this, and engineering encourages it, war may become, if not peace, at least no more violent than spirited interservice rivalry — a mighty healthy thing.

Colin Carmichael
EDITOR

The cardinal rule: Deal with sales

engineering and sales: *war or peace?*

Do your engineering and sales departments work together harmoniously? Or are they always at swords' points? Here is a candid look at the main causes of friction between the two groups and what engineers can do to help smooth relationships.

GEORGE C. LENNOX
Manager of Engineering
Lux Time Div.
Robertshaw-Fulton Controls Co.
Waterbury, Conn.

FRICTION between engineering and sales departments of a company can develop for a number of reasons. Too frequently, the engineer seems to have the feeling that the salesman is an over-paid, traveling playboy, expecting miracles in product design and reporting unreasonable field complaints in an irrational manner and with no realization of the complex nature of product creation and design. On the other hand, the commercial man often believes the engineer to be a dreamer who tends to disregard the real needs of the market and, as a result of leisurely "scientific" puttering, never comes close to meeting any kind of a schedule.

When such attitudes prevail, relations between the two departments are bound to suffer, leading to situations ranging from mild distrust to outright antagonism. Obviously, these conditions cannot be anything but detrimental to overall company efficiency.

Engineering managers should recognize the basic differences between the two operations and the types of personalities involved. Then, by training project and design engineers to have a better understanding of the sales function and to use a few techniques of communication and project handling, closer harmony will be obtained.

Creating Products vs. Creating Sales

Much of the misunderstanding and friction that

Circle 17-1 on Page 19 for extra copy.

as a customer; if engineering can't "sell" and deliver its products

12 rules for Winning Friends in the Sales Department

Product Review

1 ***Don't try to "sell" or demonstrate a product or idea from manufacturing drawings or engineering sketches.***

An engineer may be able to visualize the appearance or operation of a completed product from sketches. But commercial people will understand and accept a product idea more readily when it is demonstrated by a mock-up or sample.

2 ***Avoid unnecessary distractions when presenting new concepts in mock-up or sample form.***

For example, when a device with a new method of actuation is being presented to sales, don't have it painted green when all similar previous products have been black. If engineering believes green should be considered as a product color, that idea should be handled as a separate subject for discussion at some other time after a decision on the basic product proposal has been obtained.

3 ***Present all the possibilities.***

A selective decision is easier to make than a "yes" or "no" judgment on one proposal. When a single design approach is submitted for a decision as to whether or not it should be tooled, the conservative answer is liable to be "no" or "delay pending further study." However, when several possible designs are submitted, the decision to proceed is a selective one on the part of the marketing manager. Moreover, factors not recognized by engineering occasionally may make a second product choice the most favorable market risk.

4 ***Explain any discrepancies in the proposal.***

If a mock-up or sample has some undesirable feature which the final product will not have, make this feature clear to sales, preferably before it is recognized and a negative reaction is developed. Sometimes, even if a feature of the presentation is explained as one which will not be incorporated in the ultimate product, it becomes too much of a distraction. In such situations, the form of the presentation may have to be reworked before a favorable reaction is received.

5 ***Be honest about proposal.***

Present not only the advantages but also any and all disadvantages. If the shortcomings cannot be "sold" at this point and become incorporated into a design without the knowledge of sales, they will only cause future trouble and sales will have cause to distrust future proposals.

6 ***Do not present a proposal prematurely.***

Suppress the urge to show something that "looks good." Sales is interested in products that can be sold, not in a demonstration of engineering creativity. So often, sales inquires as to how a project is progressing and is told that the unit shown to them six months before "wasn't feasible" or "we are working on a better approach." Allow adequate time for engineering review, testing, and manufacturing feasibility studies before demonstrating a new product to the sales department. When a product that is still in the early development stages must be presented, emphasize its true status and the need for subsequent testing, review, and verification.

develops between commercial and technical people stems directly from the different working environments in which each functions, and the divergent abilities and personalities required for success in each field.

Engineers work with products created from materials and based on physical laws and properties.

Sales are created through the application of "the humanities," the interaction of personalities, and the negotiation of prices. The details of product design and how they compare to competitive products are of much less consequence than generally believed by technical personnel.

The discerning engineering supervisor or project engineer recognizes that the sales job is a strenuous one, involving much pushing from one purchasing agent's office to another, haggling with customers' quality-control groups, and trying to interpret their engineering department's needs. Evenings are often spent sitting in a hotel room writing up "call" reports and field complaints, and trying to make an expense account cover all that came out of pocket. There is little time, money, or opportunity for the "entertaining" and golf often taken for granted by the technical man.

▶ Trouble Spots

A principal source of friction between engineering and sales is the product review, where engineering presents its new product designs and ideas to sales. Project engineers are often discouraged by lukewarm reaction to a new concept, or meet opposition due to a relatively unimportant aspect of

to sales, it has no reason to stay in business.

Product-Development Schedules

7 ***Be clear on sales target dates.***

Engineering should understand the importance of model changes, annual trade shows, and seasonal demand, and how they affect the introduction of new products. In conjunction with sales target dates, the number of prototypes needed or amount of production required at these dates should be determined during the product-verification procedure.

8 ***Establish a reasonable schedule.***

By analysis of projects and by keeping accurate records of past performance, engineering should be able to set up schedules that can be met a respectable proportion of the time. Sufficient time should be allowed for the unforeseen delays. However, schedules should not be "padded" to the point where they are meaningless or unacceptable to sales and management.

9 ***Determine priorities.***

Usually the relative priority of projects will affect the time required to process each one through its development stages. Sales and engineering must reach an agreement on such priorities. When the urgency of a new project affects schedules of other programs, the situation should be reviewed with the sales department. When projects are being handled for more than one sales group, management should be called in occasionally to review relative priority of projects.

10 ***Allow reasonable time for tooling.***

Sufficient time should be programmed for all in-shop and purchased tooling. The manufacturing group should furnish or accept the estimate with an understanding of other tooling requirements which may be required concurrently.

11 ***Allow sufficient "debugging" time.***

Previous experience should indicate a reasonable amount of time for elimination of assembly problems, tool corrections, and necessary design changes. Don't expect a project to be the one job that "falls together."

12 ***Keep Sales informed of progress.***

In addition to the normal reports on status of design projects, report any changes in status, completion of a stage of development, or unusual delays. Do not wait until a commitment date approaches before reporting that a project will not be ready on time. As soon as it becomes apparent that there will be a problem in meeting schedules, sales should be notified. If possible, a proposal should be prepared on what additional effort, such as overtime and outside assistance, would be required to bring the project back into schedule.

the proposal. On the other hand, the sales department frequently is misled as to what they should expect in the final product, or as to when it will be available. Sometimes, the situation will arise where sales will prematurely introduce or "sell" a product which has not completed development and may require radical revision before first production.

The failure of engineering to meet product development schedules is another serious cause of friction between the two departments. Sometimes, improved communications between the departments can help to alleviate part of the problem, but it is not the total answer.

The trouble spots in both of these problem areas can be minimized by following a few practical rules, which are presented with this article.

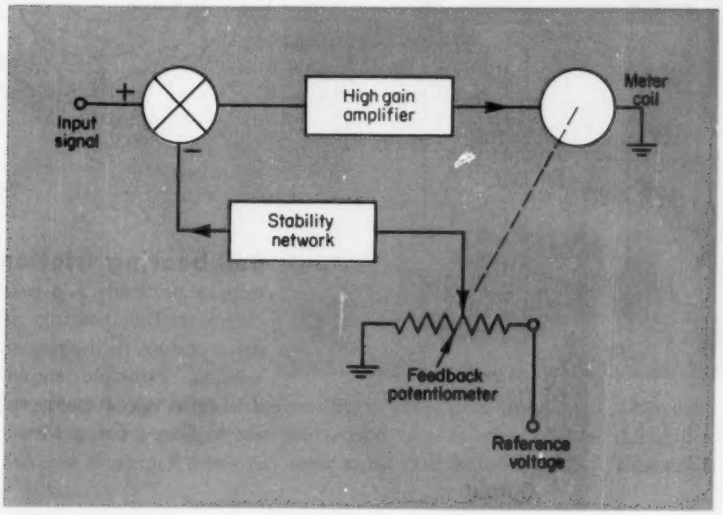
What Engineering Can Expect

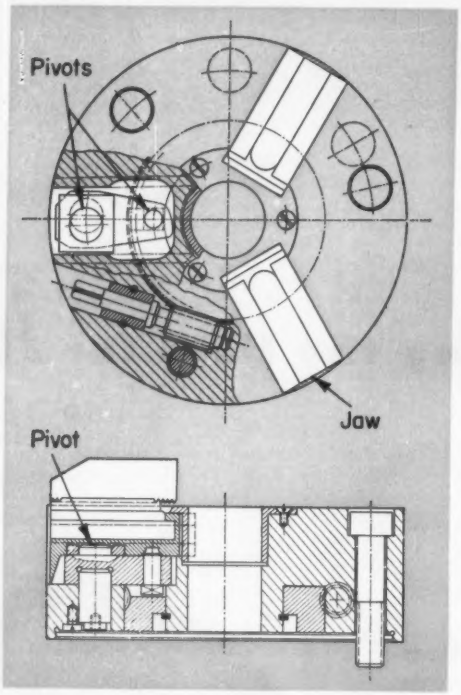
The road to improved interdepartmental relations is not a one-way street. Sales must fulfill its role as a partner in the product team. Here are some of the things that the engineer has a right to expect from the salesman:

1. A reasonable degree of understanding of the product and its application. Success in selling technical products requires this understanding, in addition to the usual qualities of salesmanship.
2. An appraisal of the market for new product possibilities, including weaknesses and strengths of competitor's units.
3. Advice and counsel during product development on design features or characteristics which might result in complaints.
4. Sympathetic handling of field complaints, with consideration for both the customer and the company's manufacturing operation.
5. Suggestions for new applications of existing products with a minimum of required modifications.
6. Appreciation of and tolerance for the difficulties encountered by the design and manufacturing departments when a new product, involving advanced design concepts and relatively untried materials and manufacturing techniques, is being introduced.

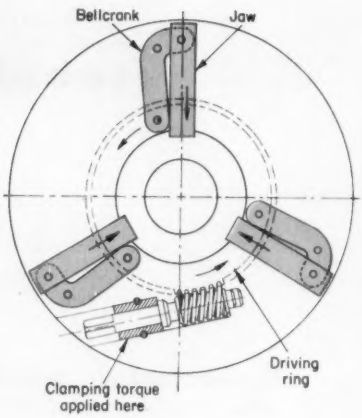
scanning the field for *ideas*

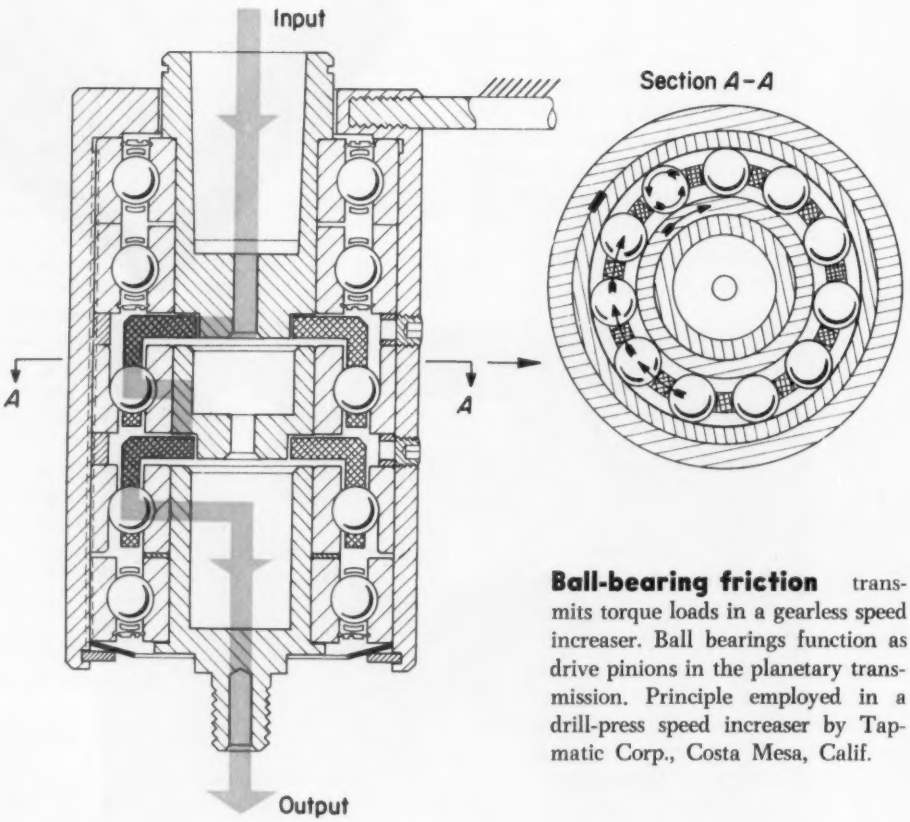
Coil-actuated potentiometer replaces force-balance system in a galvanometer. The input signal is compared to a voltage obtained from the coil-actuated potentiometer. If the position of the meter movement does not correspond to the position called for by the input signal, an error will exist. The error signal is amplified and used to drive the meter coil to a position at which the output voltage from the connected potentiometer equals the input signal voltage. Principle employed in a galvanometer by Computer Instruments Corp., Hempstead, N. Y.



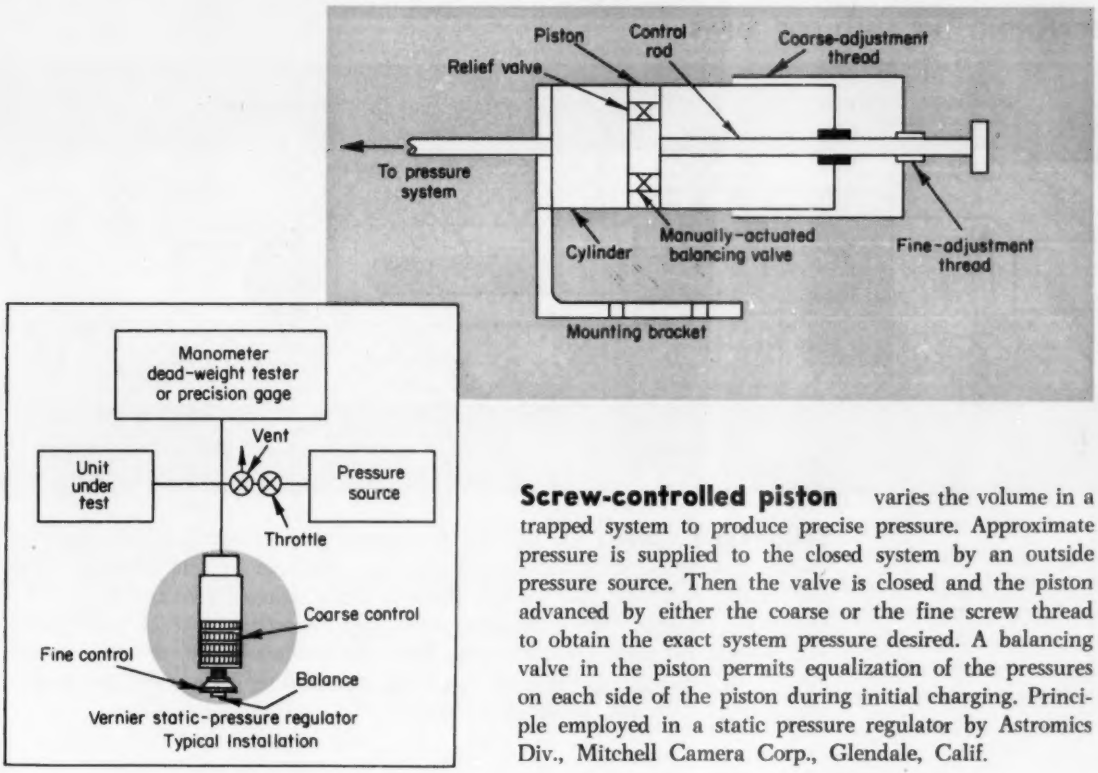


Ring-driven bellcranks produce high clamping force. Mechanical advantage is provided by the combination of bellcranks and the worm-gear drive to the bellcrank ring. Principle employed in a three-jaw chuck by Paul Forkardt K. G., Duesseldorf, Germany.

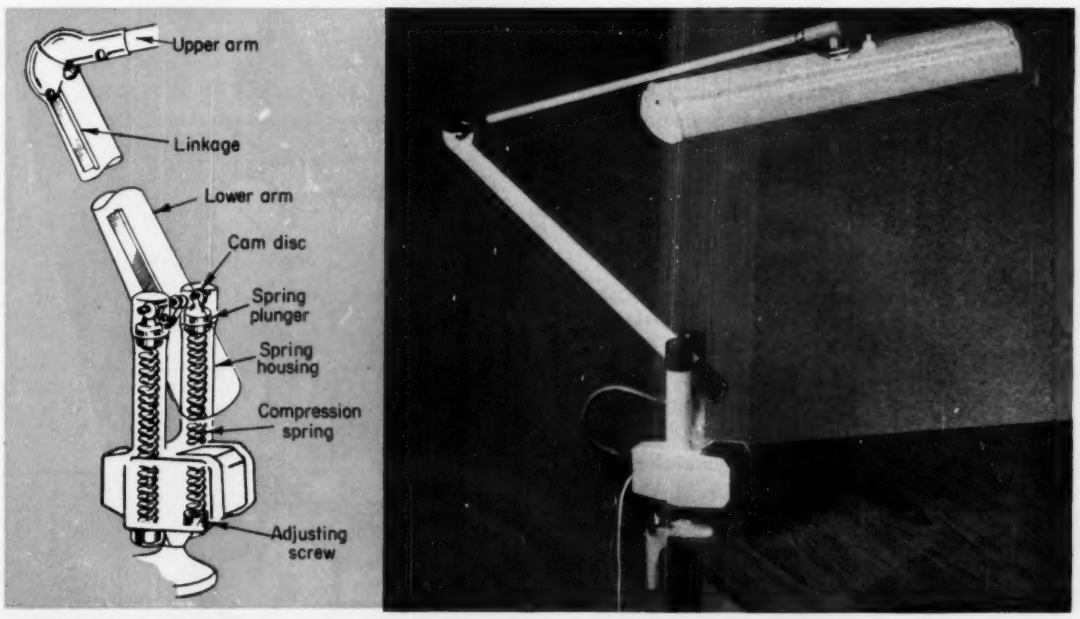




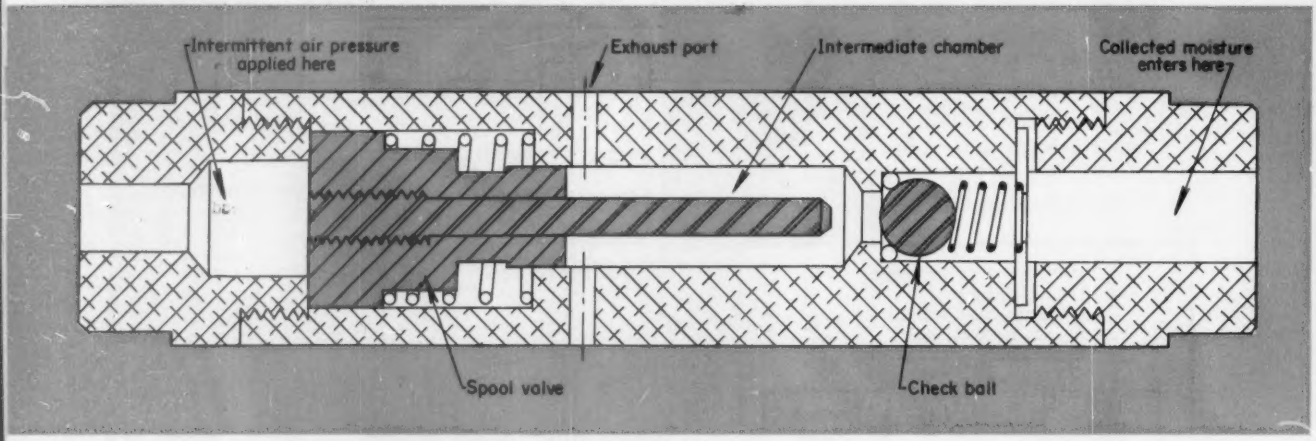
Ball-bearing friction transmits torque loads in a gearless speed increaser. Ball bearings function as drive pinions in the planetary transmission. Principle employed in a drill-press speed increaser by Tapmatic Corp., Costa Mesa, Calif.



Screw-controlled piston varies the volume in a trapped system to produce precise pressure. Approximate pressure is supplied to the closed system by an outside pressure source. Then the valve is closed and the piston advanced by either the coarse or the fine screw thread to obtain the exact system pressure desired. A balancing valve in the piston permits equalization of the pressures on each side of the piston during initial charging. Principle employed in a static pressure regulator by Astromics Div., Mitchell Camera Corp., Glendale, Calif.

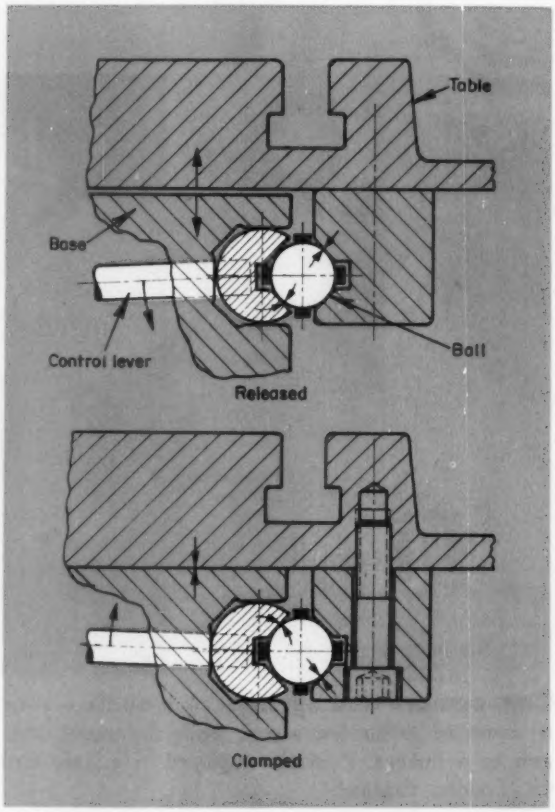


Cam-compressed springs counterbalance arms of a desk lamp. One cam is connected to the lower arm, while the second cam is connected to the upper arm by a linkage. Principle employed in a lamp distributed by M. J. Glover & Co., London, England.

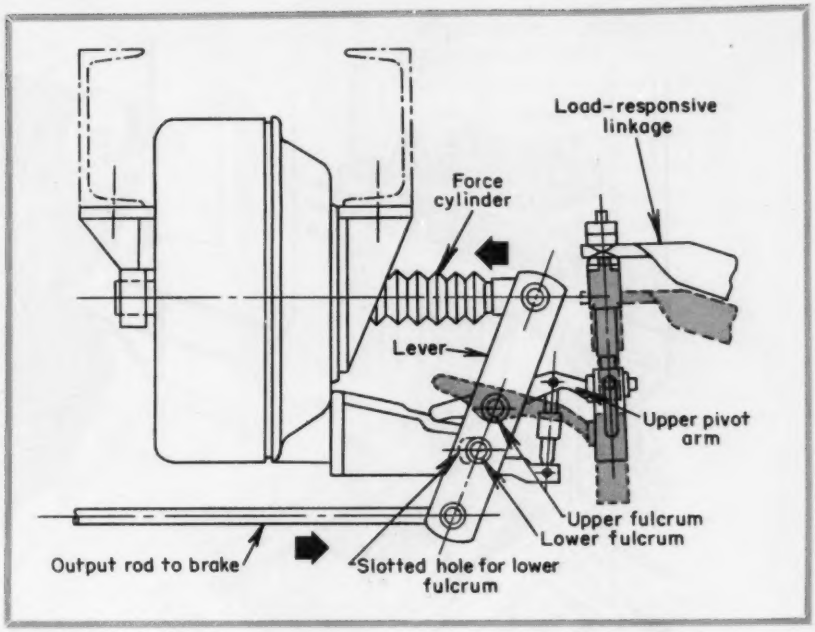


Sequenced valves use pressure fluctuation of an intermittent air supply to operate a moisture drain valve. A spool valve, displaced by line pressure, closes the exhaust ports and opens a ball check to drain collected moisture into an intermediate chamber. When the line pressure is removed, the check valve closes and the exhaust ports are uncovered. Thus, the pressure system is never opened directly to atmosphere. Principle employed in moisture drain valve by Barger Manufacturing Co. Inc., Minneapolis, Minn.

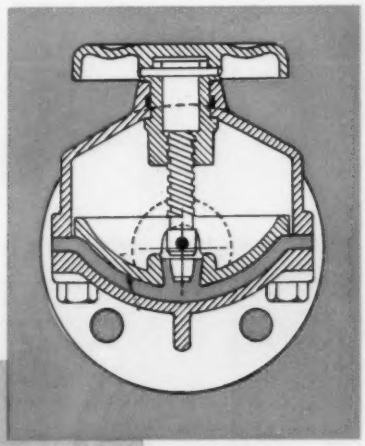
Pivoted bearing races can be rotated to clamp or release a traverse table in relation to the base. When the control lever is rotated counterclockwise the table is supported by the ball bearings, but is free to move. Clockwise rotation of the control levers locks the table to the base. Principle employed in a boring machine by VEB Werkzeugmaschinenfabrik Saalfield, Saalfield, East Germany.

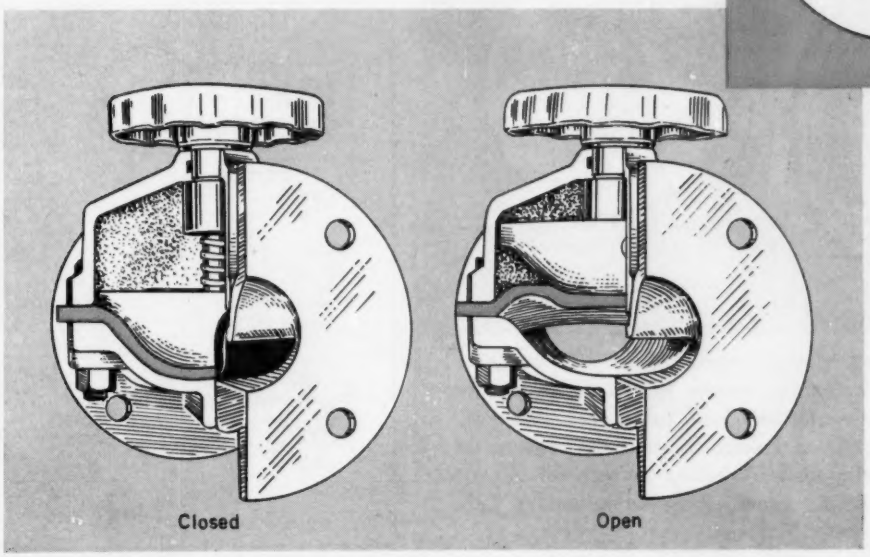


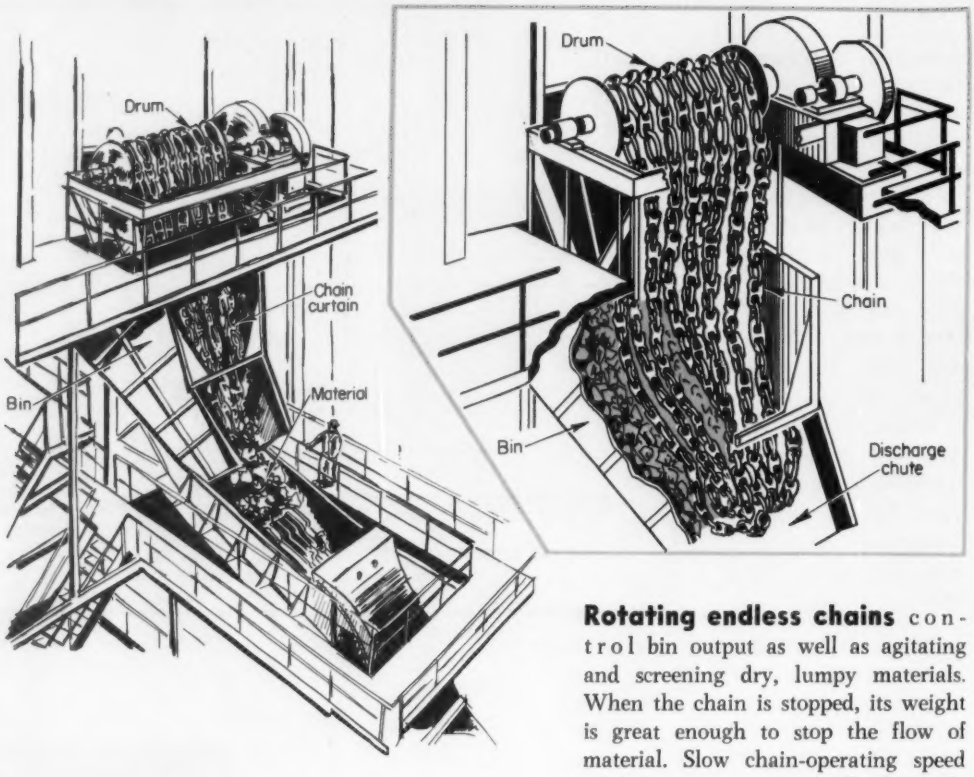
Alternate fulcrum changes ratio of a linkage to compensate brake action for a loaded or empty railroad car. At no load, the lever pivots about the upper fulcrum. When a load is applied, the upper pivot arm is rotated clockwise and the lever pivots about the lower fulcrum. Principle employed in a railroad disc brake developed by the British Transport Commission, Darlington, England.



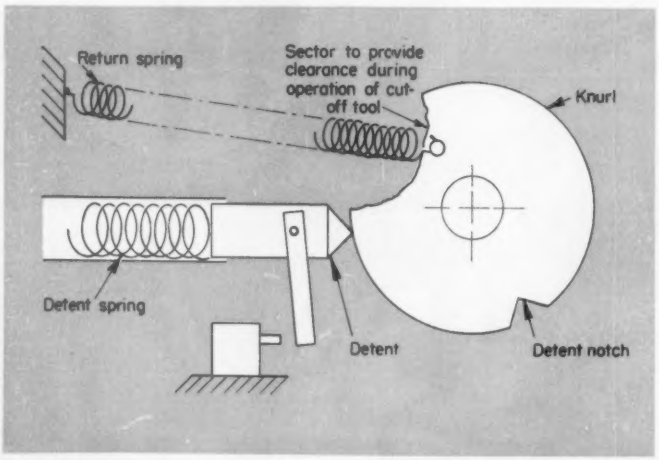
Plug retracts diaphragm to permit unobstructed flow in the open position of a valve. A projecting ring near the center of the concave face of the diaphragm permits the plug to pull the diaphragm from the flow passage. Principle employed in a valve by Automotive Rubber Co. Inc., Detroit, Mich.



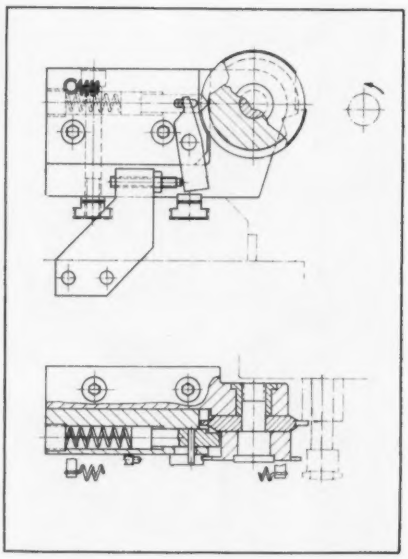


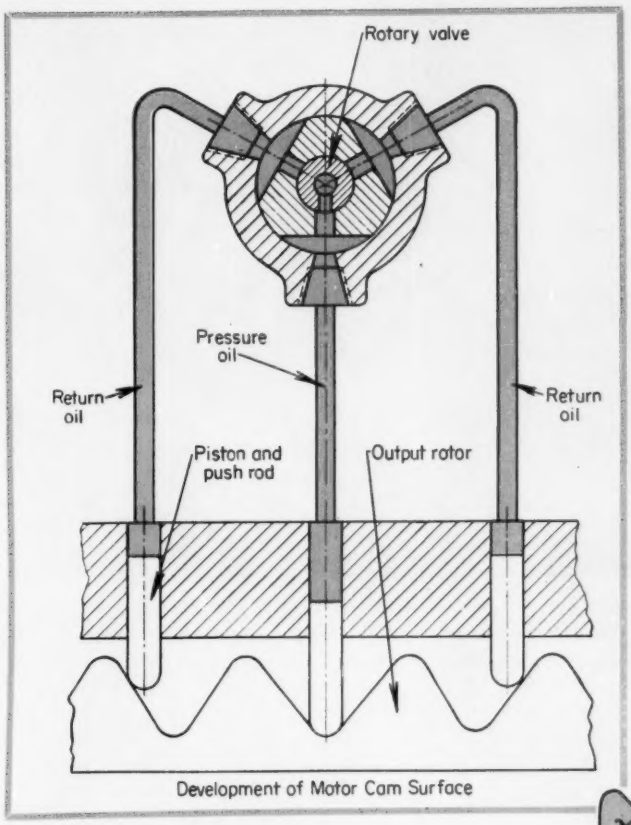


Rotating endless chains control bin output as well as agitating and screening dry, lumpy materials. When the chain is stopped, its weight is great enough to stop the flow of material. Slow chain-operating speed minimizes power required. Principle employed in a design by Kloeckner-Humboldt-Deutz A. G., Cologne, Germany.

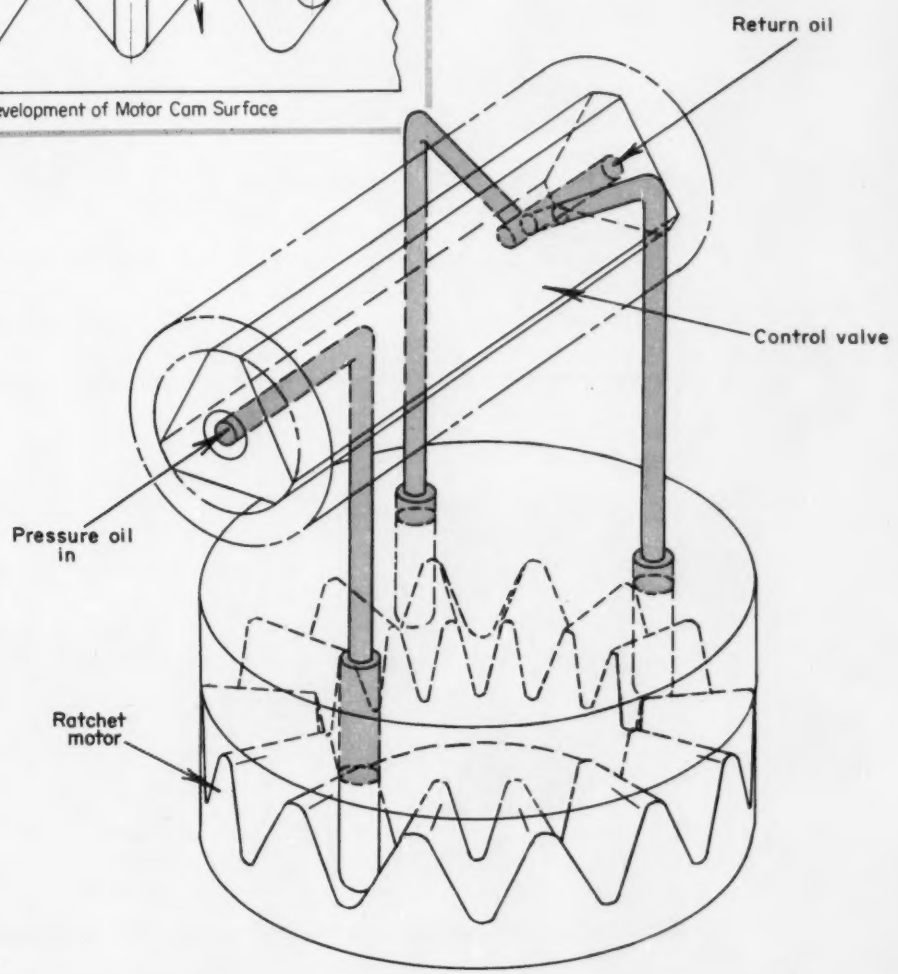


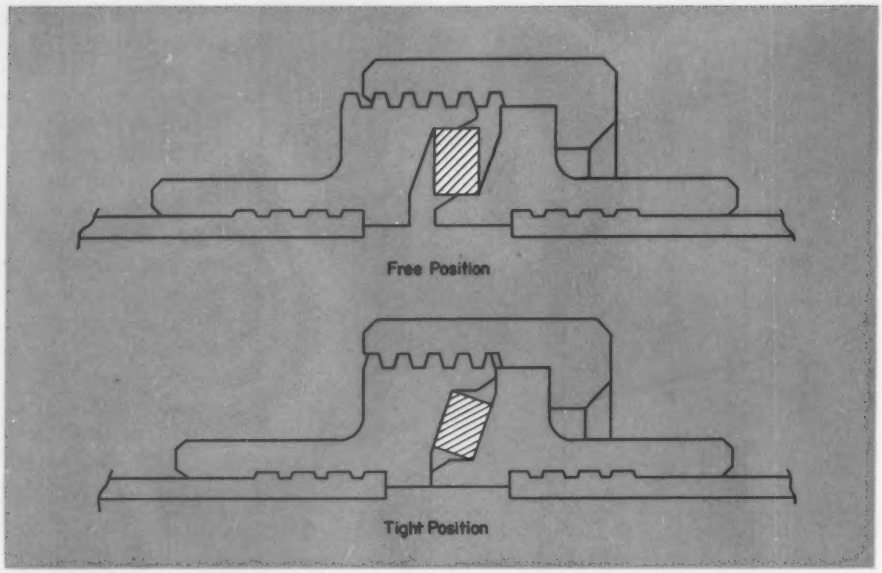
Snap-back spring powers return cycle of a rotary knurling tool. The self-driven knurl rotates to a detented position which provides clearance for a second, cutoff tool. When the tool holder is withdrawn, a linkage arrangement releases the detent so that the spring-loaded knurling tool can rotate to its original position. Principle employed in an automatic lathe by Wickman Ltd., Coventry, England.





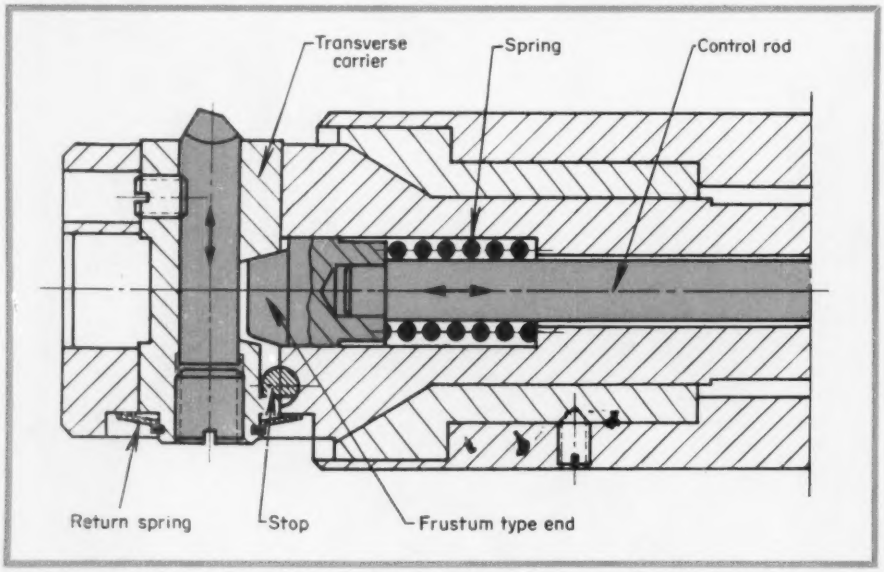
Hydraulic ratchet provides reversible stepped rotary-motion output. A rotary valve directs pressure oil to one motor cylinder and opens remaining cylinders to the sump. Piston and cam configuration permits output rotor to be turned in either direction, in response to direction of control-valve rotation. The output rotor is hydraulically locked until the control valve reaches the next position. Principle described in *Stanki i instrument* magazine, Moscow, Russia.





Deformed metal ring seals a tube fitting for cryogenic or high-temperature applications. Resilience of the ring provides locking action against vibration and pressure surges. Principle employed in a coupling by Gamah Corp., Santa Monica, Calif.

Inverted detent produces output motion that is perpendicular to direction of input force. When the control rod is forced into the conical hole in the carrier, the carrier is moved laterally. Principle employed in a boring tool carrier by VEB Werkzeugmaschinenfabrik Vogtland, Plauen/Vogtland, East Germany.



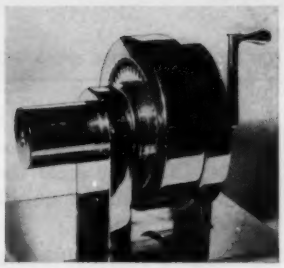
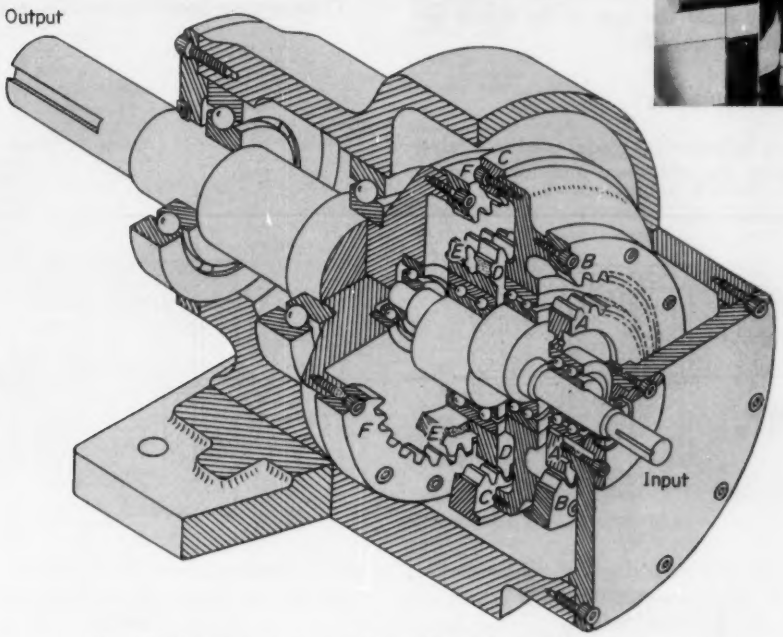


Fig. 1—Double-eccentric speed reducer. Counterweights for eccentric masses are not shown in cutaway.Photo, right, shows working model.



- *Extreme speed-reduction ratios*
- *High efficiency*
- *Standard parts . . .*

The Double-Eccentric Speed Reducer

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Louisiana Polytechnic Institute
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THE double-eccentric speed reducer represents a unique concept in the use of standard gear components to achieve extreme-speed reduction. This patented reducer, Fig. 1, consists essentially of three internal gear sets connected by a double-eccentric, or double-crank, drive arrangement. The result is a compact unit offering high efficiency over a range of reduction ratios extending to more than 500,000:1. Fig. 2 shows eight different arrangements of the three fundamental gear sets.

• Basic Relationships

The inset photograph Fig. 1, shows a hand-driven prototype constructed to illustrate the double-eccentric principle. It is of the type shown in Fig. 2*b*.

For large speed reductions, the arrangement shown in Fig. 2*c* can be used. From this arrangement, an expression can be obtained, using standard methods, for the speed reduction of this drive. The procedure is shown in Table 1.

From Table 1, the speed reduction or velocity ratio, m, is

$$m = \frac{1}{1 - \frac{ace}{bdf}} \qquad (1)$$

where lower-case letters represent number of teeth.

If all gear sets in the drive have the same diametral pitch, the following relationship must hold true if the gears are to mesh properly:

$$b - a + f - e = c - d \qquad (2)$$

or

$$a + c + e = b + d + f \qquad (3)$$

Equation 3 can be modified by inspection to fit any arrangement of the component gear sets. Only

the signs of the terms in the equation vary. It is only necessary to remember that center distance in gear set *CD* must equal the sum of the center distances in gear sets *AB* and *EF*.

• Analysis and Synthesis

Fig. 3 shows a hypothetical model used in analytically investigating the efficiency and torque-to-size characteristics of a typical unit. For this design, requirements are: speed reduction $m \approx 1760$; output torque = 10,000 lb-in. at 1 rpm.

Determining Speed Ratios: From Equation 1,

$$1760 \approx \frac{1}{1 - \frac{ace}{bdf}}$$

or

$$\frac{1}{1760} \approx 1 - \frac{ace}{bdf} = \frac{bdf - ace}{bdf}$$

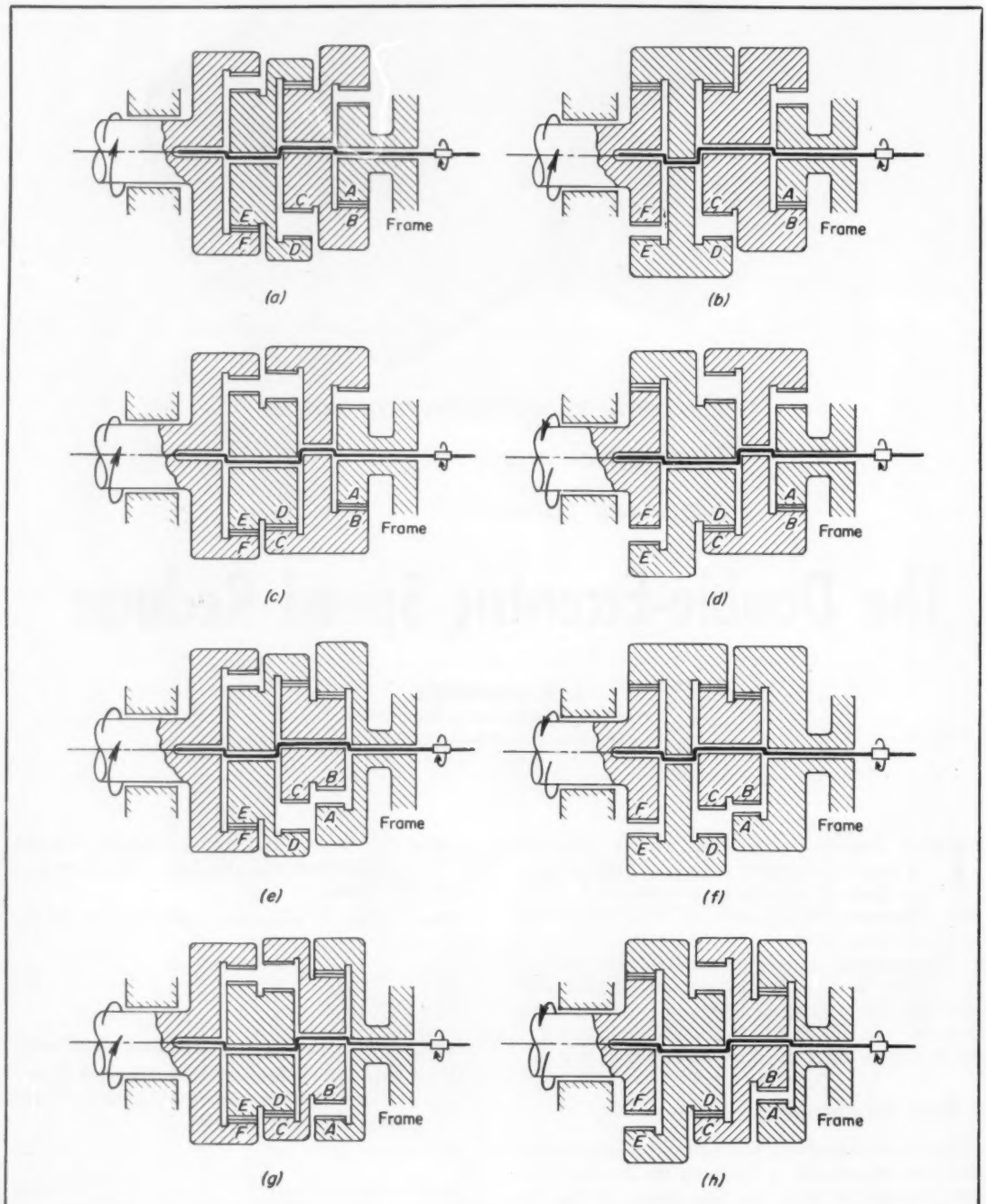


Fig. 2—Typical arrangements of the three gear sets of a double-eccentric speed reducer.

Characteristics of the Double-Eccentric Reducer

- Wide variation of speed ratios is possible. By varying the arrangement of gears as shown in Fig. 2, and by selecting proper tooth numbers (Equations 1 and 2), speed reductions of less than 2:1 to over 500,000:1 may be obtained.
- Efficiency of the drive at high reduction is comparable to that of most standard gear-reduction units.
- The drive consists of three internal gear sets which may be produced on standard gear-generating equipment. The input to the drive is through a simple double-throw crankshaft which presents no special production problems. The eccentric masses may be easily balanced by the use of weights in two accessible planes.
- There is no internal redundancy in the system and, consequently, no circulating power loss.
- All rotating gearing elements have low angular velocities as compared to the input speed. This results in low average sliding velocities between the contacting gear teeth.

Next, two consecutive numbers, n and $(n - 1)$, are found so that

$$\frac{k}{k}\,\frac{n-1}{n} = -\frac{ace}{bdf}$$

where k and n are factors of the numerator of the speed-reduction ratio. From a table of factors, 1763 and 1764 are found. From this,

$$\frac{ace}{bdf} = \frac{(82)(86)(82)}{(84)(82)(84)} = \frac{1763}{1764}$$

Substituting in Equation 2,

$$82 + 86 + 82 = 84 + 82 + 84$$

As a final check, from Equation 1,

$$m = \frac{1}{1 - \dfrac{(82)(86)(82)}{(84)(82)(84)}} = 1764$$

In this example, sets *AB* and *EF* both have a difference of only two teeth. Such sets will operate without interference through the use of standard high-strength, 25-deg pressure angle gears (AGMA 201.02), modified to stub-tooth proportions. With the pinion driving, the optimum design for strength and efficiency would result from the use of a relatively long addendum on the pinion, with a proportional increase in tooth thickness along the pitch circle. The increase in efficiency results from a decrease in sliding velocity at the initial point of contact, where the normal tooth load is near the maximum. These modifications do not affect the use of standard 25-deg tooling.

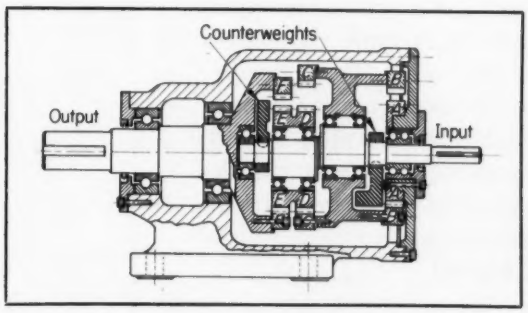


Fig. 3—Double-eccentric speed reducer for reduction ratio 1764:1.

Table 1—Determination of Velocity Ratio

	Input	Frame	Number of Turns Gear B	Gear C	Gear D	Gear E	Gear F
		A					
All elements given one positive turn	+1	+1	+1	+1	+1	+1	+1
Input fixed, frame given one negative turn	0	−1	$-\frac{a}{b}$	$-\frac{a}{b}$	$-\frac{ac}{bd}$	$-\frac{ac}{bd}$	$-\frac{ace}{bdf}$
Total turns	+1	0					$1-\frac{ace}{bdf}$

Table 2—Computed Velocity Ratios*

Ratio	Number of Teeth Gear A	Gear B	Gear C	Gear D	Gear E	Gear F
∞	107	110	110	103	103	107
599.687	103	110	110	101	93	95
1,595.166	103	110	109	100	94	96
49,568.750	107	110	109	103	102	105
549,505.000	108	110	106	97	96	103
−2.837	92	100	30	20	98	100
−43,120.000	107	110	104	98	93	96
−636.428	92	100	100	90	97	99
−561,000.000	107	110	107	102	98	100

*For gear arrangement shown in Fig. 2c. Negative signs indicate that output shaft rotates in direction opposite to input.

Preliminary Strength Calculations: For an output torque of approximately 10,000 lb-in. the transmitted tangential load, W_t, through the final gear set *EF*, Fig. 3, is

$$W_t = \frac{10{,}000}{r_f}$$

where r_f is the pitch radius, in.

The Lewis equation, modified by the Dolan and Broghamer stress-concentration factors determined for the 25-deg stub-tooth form, yields a calculated face width of approximately $1\frac{1}{8}$ in. This is based on a diametral pitch of 10, and a design stress of 50,000 psi.

Efficiency: The efficiency calculations for the units analyzed were based on coefficients of friction reported in the literature*. The efficiency of the speed reducer shown in Fig. 3 was determined analytically to be approximately 90 per cent. The analysis followed, in principle, the method credited to W. H. Clapp by Buckingham in his classical treatment of the subject*. This efficiency value of 90 per cent is believed to be conservative, since all assumptions, such as coefficients of friction, are conservative.

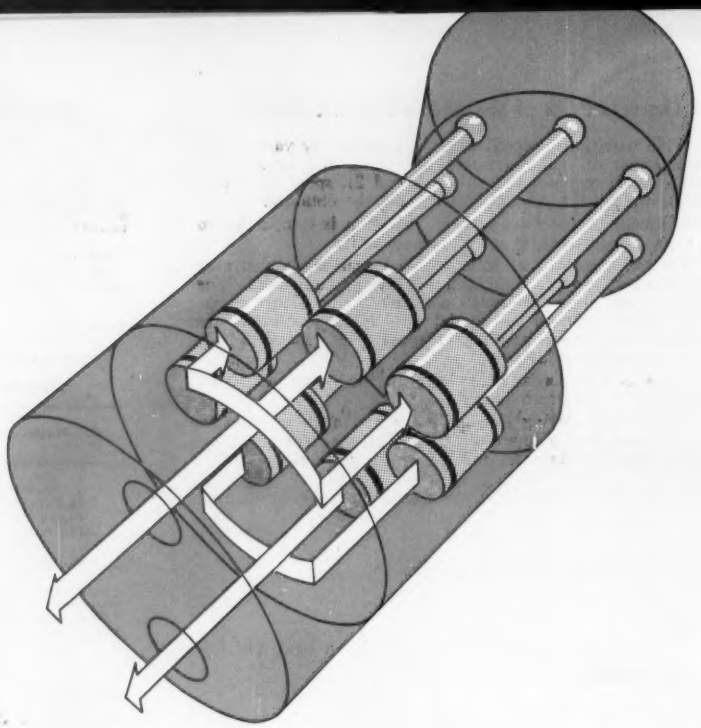
Calculated Ratios: A computer program has been set up to find velocity ratios corresponding to gear-tooth numbers in the double-eccentric speed reducer. Although all possible values were not printed out, the wide range of available ratios was demonstrated.

Table 2 shows representative values obtained from computer calculations.

*E. Buckingham—*Analytical Mechanics of Gears*, McGraw-Hill, New York, 1949.

ACKNOWLEDGEMENT

The author acknowledges with appreciation the co-operation of the Temple Iron Works, Shreveport, La., in furnishing preliminary technical information. He also wishes to thank J. R. English and Walter Stagg Jr., who developed the digital-computer program mentioned in the article.



Hydraulic Pumps and Motors

Part 1—A new, graphical method as a selection aid

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Three important factors must be considered in the selection of a hydraulic pump or motor: 1. Viscosity of the fluid. 2. Pump speed. 3. Pressure differential between inlet and outlet. These requirements can be expressed in terms of three nondimensional performance coefficients. Since pump and motor capabilities can also be rated in these same coefficients, they provide a convenient graphical selection method.

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PERFORMANCE characteristics of hydraulic pumps and motors can be expressed in terms of nondimensional coefficients.* These coefficients are general and can be used to predict the performance of hydraulic pumps, motors, motor-pump combinations, and hydrostatic transmissions.

This article presents a simplified method for determining these nondimensional parameters and discusses the significance of their values.

Basic Relationships: Pump performance can be described by these equations:

$$Q = DN - \frac{C_s \Delta p D}{2\pi\mu} \quad (1)$$

and

$$T = \frac{(1 + C_f)\Delta p D}{2\pi} + C_d D \mu N \quad (2)$$

For fluid motors, the sign of the second term in the right hand side of Equations 1 and 2 is reversed.

The maximum over-all efficiency that can be developed by a pump is

$$E_{mp} = 1 \Big/ \left[1 + Cf + 2C_s C_d \left(1 + \sqrt{1 + \frac{1 + C_f}{C_s C_d}} \right) \right] \quad (3)$$

*W. E. Wilson—"Hydraulic Pumps and Motors," MACHINE DESIGN, Vol. 21, No. 1, Jan., 1949, p. 133.

Nomenclature

C_d = Coefficient of dry friction, nondimensional
C_f = Coefficient of viscous friction, nondimensional
C_s = Coefficient of slip, nondimensional
D = Displacement, units of volume per revolution
E_{mm} = Maximum efficiency of motor
E_{mp} = Maximum efficiency of pump
N = Shaft rotation, revolutions per unit time
Δp = Pressure differential, units of force per unit area
Q = Flow, units of volume per unit time
T = Torque, units of distance time force
Z_m = Value of the ratio, $2\pi\mu N/\Delta p$, at which the maximum over-all motor efficiency occurs
Z_p = Value of the ratio, $2\pi\mu N/\Delta p$, at which the maximum over-all pump efficiency occurs
μ = Dynamic viscosity, units of mass divided by length and time

For a hydraulic motor this equation becomes

$$E_{mm} = 1 - C_f + 2C_s C_d \left[1 - \sqrt{1 + \frac{1 - C_f}{C_s C_d}} \right] \quad (4)$$

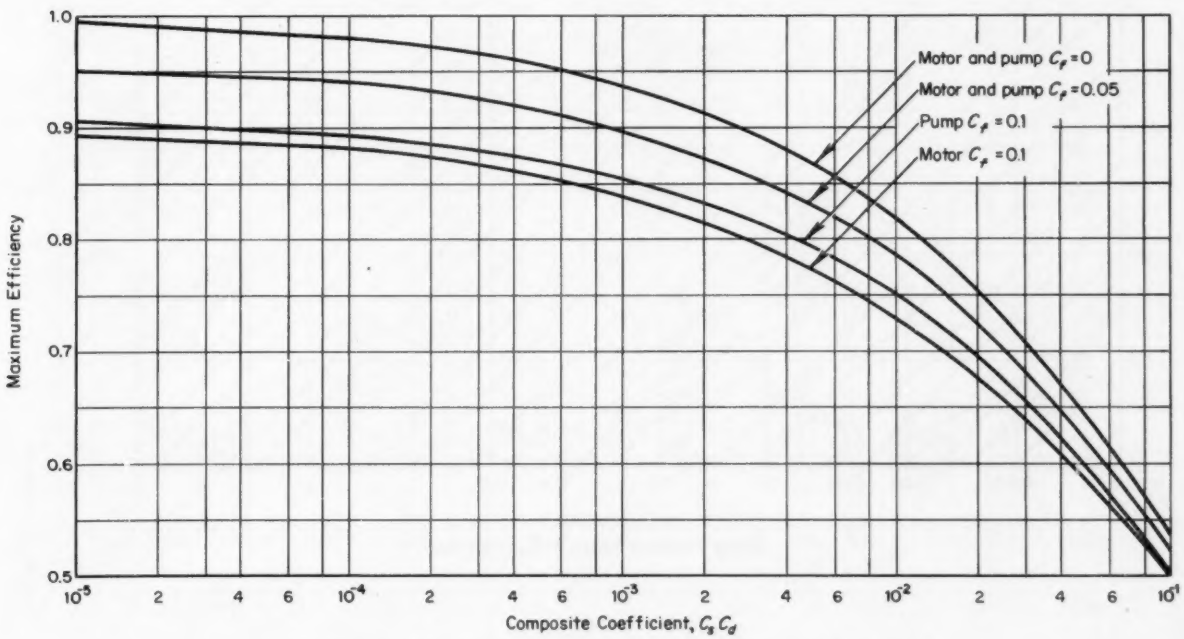

Fig. 1—Maximum efficiency vs. composite coefficient $C_s C_d$ for various values of C_f.

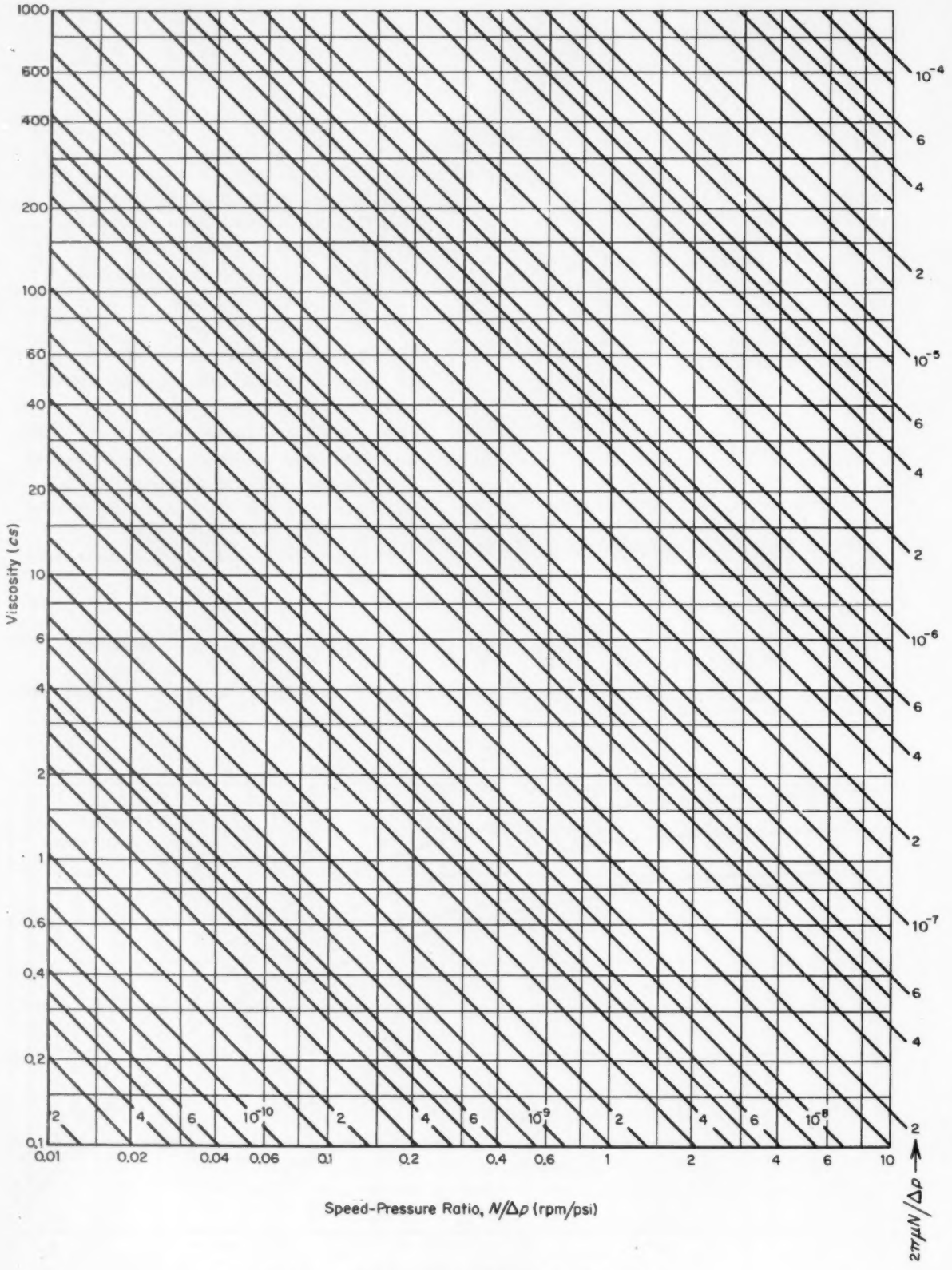

Fig. 2—Ratio $2\pi\mu N/\Delta p$ as a function of viscosity and speed-pressure ratio. Specific density of the liquid is assumed to be 0.9.

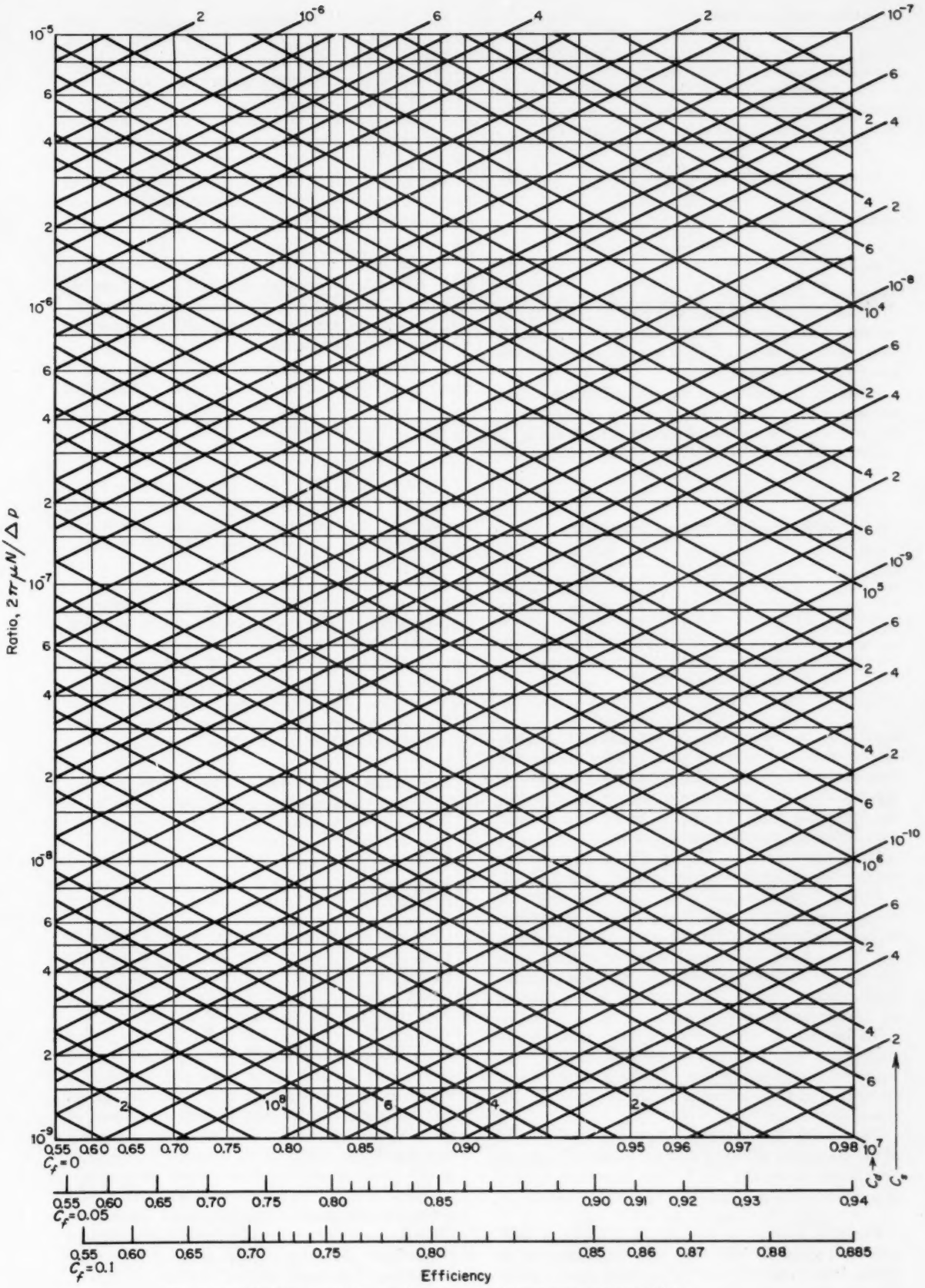

Fig. 3—Coefficients C_s and C_d as a function of efficiency and ratio $2\pi\mu N/\Delta p$

Equations 3 and 4 are plotted in Fig. 1.

The maximum value of the over-all efficiency occurs at particular values of the ratio $2\pi\mu N/\Delta p$. For a hydraulic pump, the value of the ratio is:

$$Z_p = C_s \left[1 + \sqrt{1 + \frac{1 + C_f}{C_s C_d}} \right] \quad (5)$$

and for a hydraulic motor,

$$Zm = C_s \left[-1 + \sqrt{1 + \frac{1 - C_f}{C_s C_d}} \right] \quad (6)$$

Performance Parameters: The best efficiency is obtained when composite coefficient C_sC_d is as small as possible. Coefficient C_sC_d is a good measure of the quality of the pump or motor.

However, the location of the peak efficiency within the operating range is not a function of C_sC_d only, but rather of the individual values of C_s and C_d.

Composite coefficient C_sC_d is proportional to the square of the clearances in the pump or motor. Hence, the smaller the clearances, the higher the possible maximum efficiency. However, if peak efficiency does not occur at the proper point within the operating range, a pump or motor with a lower peak efficiency may be more desirable.

Table 1—Performance Coefficients

Type	C_s	C_d	C_f	Performance
Vane Pump	9×10^{-7}	2×10^{6}	0	10 gpm, 1000 psi at 1800 rpm
Gear Pump	2×10^{-9}	3×10^{6}	0	7 gpm, 1200 psi at 1200 rpm
Piston Pump	9×10^{-10}	2×10^{6}	0	29 gpm, 3000 psi at 600 rpm
Vane Motor	1.5×10^{-7}	1.5×10^{6}	0.1	24.8 gpm, 2000 psi at 3600 rpm
Gear Motor(1)	3×10^{-7}	10^{5}	0.19	20 gpm, 1200 psi at 1800 rpm
Gear Motor(2)	4×10^{-7}	3×10^{4}	0	10 gpm, 600 psi at 1200 rpm
Piston Motor	1.1×10^{-8}	4×10^{5}	0.07	5 gpm, 1100 psi at 1600 rpm

Optimum values for C_s and C_d for a particular application can be determined from Fig. 2 and Fig. 3.

In Fig. 2, pressure and speed have been converted to common working units. Viscosity is in centistokes, with an assumed specific density of 0.9. The chart can be used for liquids with specific densities from 0.8 to 1.0 without introducing significant errors. Additionally, viscosity in centipoises, rather than in centistokes, can be used directly.

To use Fig. 2, divide the speed, in rpm, by the pressure, in psi. Find the intersection of this value with the horizontal line corresponding to the liquid viscosity. Read the value of $2\pi\mu N/\Delta p$ from the inclined lines.

To use Fig. 3, locate the intersection of the value of the maximum efficiency and the value of $2\pi\mu N/\Delta p$ determined from Fig. 2. At this intersection, read the values of C_s and C_d from the inclined lines.

Example: Operating pressure of a pump is 2000 psi, shaft speed is 3000 rpm and liquid viscosity is 46 cs. Maximum efficiency is to occur at this point and must be at least 86 per cent.

SOLUTION: If C_f is assumed to be zero, then from Fig. 1, coefficient $C_sC_d = 5.6 \times 10^{-3}$ for 86 per cent efficiency. From Fig. 2, $2\pi\mu N/\Delta p = 10^{-6}$. From Fig. 3, the corresponding values of C_d and C_s are 8×10^4 and 7×10^{-8}.

Unless a pump with a value of $C_f = 0$ is known to be available, the value assumed for C_f should be at least 0.05.

Although a value of $C_sC_d = 5.6 \times 10^{-3}$ can be attained without difficulty, the necessity for a peak efficiency at $2\pi\mu N/\Delta p = 10^{-6}$ requires a low value of C_s.

If peak efficiency were required at a pressure of only 1000 psi, the required value of C_s and C_d would be 1.3×10^{-7} and 4.3×10^4. The lower operating pressure permits increased slip with a corresponding reduction in frictional drag.

If the speed were increased to 6000 rpm with a pressure of 1000 psi, the critical value of $2\pi\mu N/\Delta p$ would be 4×10^{-6}. For 86 per cent efficiency, the required value of C_s would be 2.8×10^{-7}; and of C_d, 2.3×10^4.

Application: In Fig. 3, for a given liquid, the larger values of $2\pi\mu N/\Delta p$ correspond to relatively high speeds and low pressures, whereas low values correspond to relatively low speeds and high pressures. For a given required maximum efficiency, better values of C_s (low numerically) are necessary at high pressures. At higher speeds and lower pressures, higher numerical values of C_s can be tolerated.

Table 1 lists experimentally determined performance coefficients for typical pumps and motors. The narrow range of coefficient values is due primarily to limitations of manufacturing tolerances.

Vane and gear pumps and motors have values of C_s from 10^{-7} to 10^{-6}, with values of C_d from 10^4 to 10^6.

For piston pumps and motors, C_s ranges from 10^{-9} to 10^{-7}; C_d ranges from 10^5 to 10^7.

They Say . . .

"For a long time increasing the speed of electronic systems was a matter of improving the components. Recently the speed of certain systems has reached a point where propagation delays in the wiring, rather than the characteristics of the devices, prohibit faster operation. This point is often called the speed-size ceiling and it has important bearing on computer systems. If a particular system has reached its speed-size ceiling, it is impossible to expand it functionally without decreasing its speed of operation, and vice-versa. The only way through a given speed-size ceiling is to decrease the physical size of a given system and thus shorten the propagation delay through it. Microsystem electronics, and particularly Integrated Circuitry, shows promise of substantial improvement in speed-complexity product by significant reduction of propagation delay within and between integrated circuits."—PETER B. MYERS, *Motorola Inc., Phoenix, Ariz.*

a quick, approximate method for estimating

critical speeds of coupled machines

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College of Engineering
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CONNECT two rotating machines with a mechanical coupling. What is the critical speed, or lateral natural frequency, of the system? It may be quite different from the values for the individual machines, creating a dangerous condition in the running range.

Actually, the exact value of the critical speed may not be required if it is considerably different from the running speed. For design purposes, the initial requirement is for a quick approximate method of estimating the critical speed of coupled machines. Such a method is presented here.

If this estimate indicates that the critical speed is quite different from the running speed, further analysis is unnecessary. If the calculations indicate that the critical speed is close to the running speed, a more detailed analysis should be made.

Basic Factors: The type of coupling used has a direct influence on the system natural frequency. If the coupling is large and rigid with heavy flanges and bolts, it may, in effect, be equivalent to welding the shafts together. This gives a three-span, four-support system which can be investigated by comparison with uniform beams[1] or, perhaps, by making a dynamically similar model.[2]

If the coupling is of the flexible type,[3] which permits some angular displacement of the shaft centerlines, it may not transmit bending moment across the connection. Thus, a gear, chain, or sliding-block coupling will transmit shear loading and torque from one shaft to another. But it may have sufficient flexibility so that the shaft centerline, under dynamic conditions, has an inflection point at the coupling, Fig. 1. These couplings act essentially like a hinge, enforcing the same lateral displacement of the shafts at the coupling while allowing the slope to be discontinuous.

Equivalent System: To obtain a simple mathematical model for analysis, the actual system is replaced by an approximate equivalent system. It is assumed that the coupling acts like a simple hinge located in the center of the middle span at distance L_1 from either bearing. The average ma-

[1]References are tabulated at end of article.

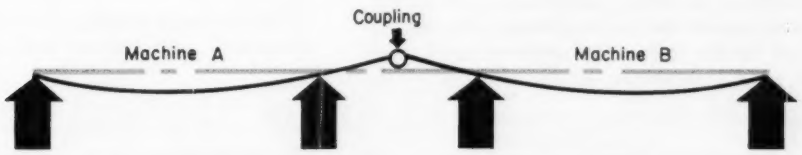

Fig. 1—Effect of flexible coupling on dynamic deflection of connected machine shafts.

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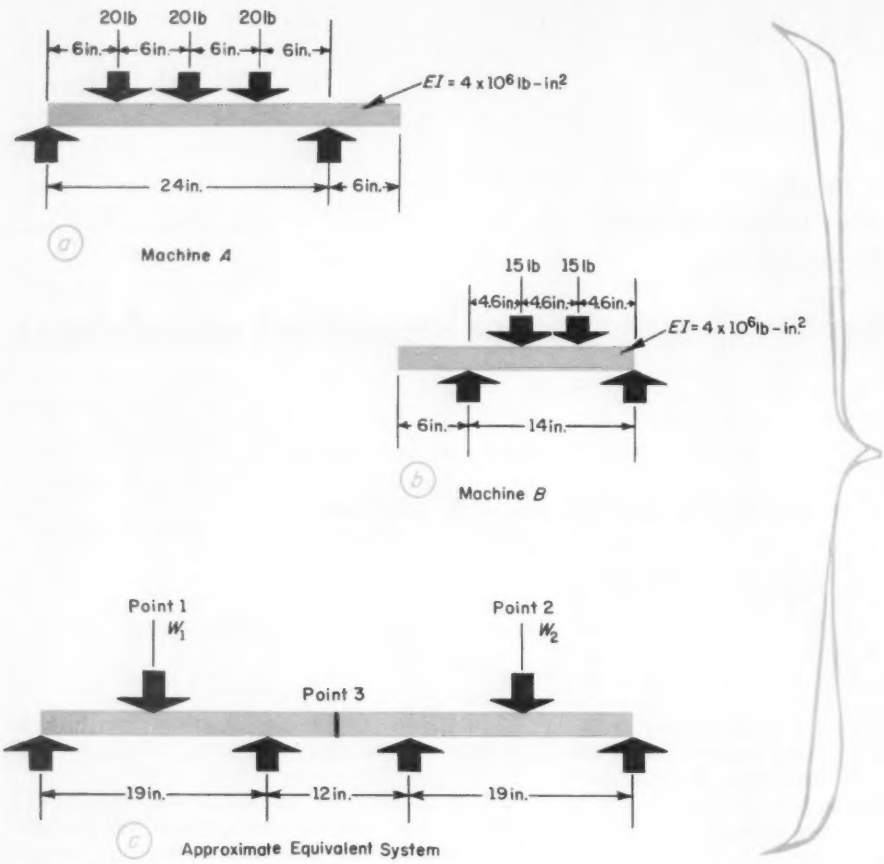


Fig. 2—Method of approximating coupled-machine system. When machine *A* is connected to machine *B* with a flexible coupling, approximate equivalent is given at *C*.

chine span length is found and assumed to be the same for each machine. In addition, the distributed loading on each machine is replaced by a single concentrated center load in the idealized model.

Fig. 2 illustrates the basic problem. Machine *A*, with a given loading and natural frequeny ω_1, is to be coupled to machine *B* which has a different loading and natural frequency ω_2. The two machines, joined by a flexible coupling, are approximated by the system shown in Fig. 2c. If the machine natural frequencies are not furnished by the manufacturer, they must be calculated as an initial step.

Rayleigh's principle is used for most common methods of estimating fundamental natural frequencies of single-span machines. Procedure is to assume that the system is vibrating at its fundamental natural frequency without loss of energy. Under these conditions, the maximum potential energy stored in the beam (as strain energy) must be equal to the maximum kinetic energies of the loads.

Natural Frequencies: Machines *A* and *B* of Fig. 2*a* and *b* will be used to illustrate one method of applying Rayleigh's principle to obtain the fundamental frequencies of the two machines. It is assumed that the dynamic deflection of the individual single-span machine will be (see Nomenclature)

$$Y = Y_o \sin \frac{\pi X}{L} \tag{1}$$

The maximum potential energy stored in the beam[4] is

$$P_p = \frac{EI}{4} \frac{\pi^4}{L^3} Y_o^2 \tag{2}$$

The kinetic energy is found by assuming that the vibration is harmonic so that the displacement of any point on the beam as a function of time is

$$Y_n = Y_o \sin \frac{\pi X_n}{L} \sin \omega t \tag{3}$$

The maximum velocity is found by differentiating Equation 3 with respect to time. Thus,

$$\frac{dY_n}{dt} = Y_o \omega \sin \frac{\pi X_n}{L} \tag{4}$$

If the shaft weight is assumed to be small compared to rotor weight, the kinetic energy of the *n*th rotor is

Table 1—Kinetic Energy Calculations

Rotor	Weight (lb)	$\pi X/L$ (deg)	$[\sin(\pi X/L)]^2$	$W[\sin(\pi X/L)]^2$
Machine *A*				
1	20	45	0.5	10
2	20	90	1.0	20
3	20	145	0.5	10
			Total	40
Total $P_k = \frac{40}{2g} Y_o^2 \omega^2$				
Machine *B*				
1	15	60	0.75	11.25
2	15	120	0.75	11.25
			Total	22.45
Total $P_k = \frac{22.50}{2g} Y_o^2 \omega^2$				

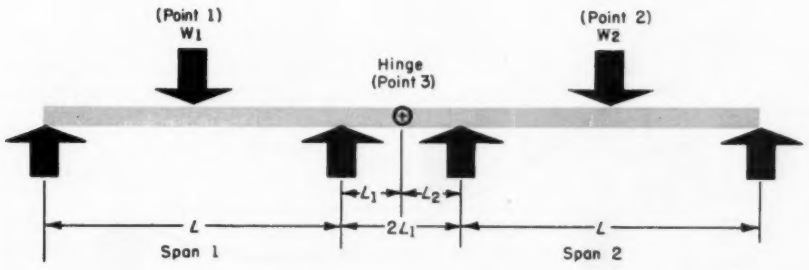


Fig. 3—Idealized system. Deflection characteristics are derived by considering each load separately.

$$P_k = \frac{mV^2}{2} = \frac{W}{g} Y_o^2 \frac{\omega^2}{2} \left(\sin \frac{\pi X_n}{L} \right)^2 \quad (5)$$

The rotor kinetic energies for the machines of Fig. 2*a* and *b* are computed in Table 1.

Equating the maximum potential energy (Equation 2) to the maximum kinetic energy computed in Table 1 gives the single-span natural frequencies of the two machines of Fig. 2. Thus, natural frequency of machine *A* is

$$\omega_1 = \left(\frac{gEI\pi^4}{80L^3} \right)^{1/2} = \frac{\pi^2(2000)}{24} \left[\frac{386}{80(24)} \right]^{1/2}$$

$$= 368.77 \text{ rad/sec} \quad (6)$$

and natural frequency of machine *B* is

$$\omega_2 = \left(\frac{gEI\pi^4}{45L^3} \right) = \frac{\pi^2(2000)}{14} \left[\frac{386}{45(14)} \right]^{1/2}$$

$$= 1103.63 \text{ rad/sec} \quad (7)$$

System Analysis: With these known values, the system can be approximated by two spans of identical length with single center weights, Fig. 2*c*. The length of each span is arbitrarily taken as the

Nomenclature

- A = Deflection factor (Equation 25)
- a = Influence coefficient, in./lb
- E = Young's modulus of elasticity, psi
- F = Shear force at flexible coupling, lb
- f_n = Natural frequency, cps
- g = Acceleration of gravity, in./sec/sec
- I = Section inertia, in.^{4}
- L = Span length between bearing centerlines, in.
- L_1 = Span length from bearing centerline to coupling, in.
- m = Mass, lb-sec^2/in.
- P_k = Maximum kinetic energy, in.-lb
- P_p = Maximum potential energy, in.-lb
- W = Weight, lb
- X = Distance from left-hand bearing, in.
- X_n = Distance from left-hand bearing to *n*th rotor or point, in.
- Y = Displacement perpendicular to shaft centerline, in.
- Y_n = Displacement of *n*th rotor or point, in.
- Y_o = Amplitude, in.
- θ = Slope of beam deflection curve, radian.
- ω = A natural frequency for freely vibrating shaft or idealized system, rad/sec
- ω_1 = Natural frequency of left-hand span, rad/sec
- ω_2 = Natural frequency of right-hand span, rad/sec

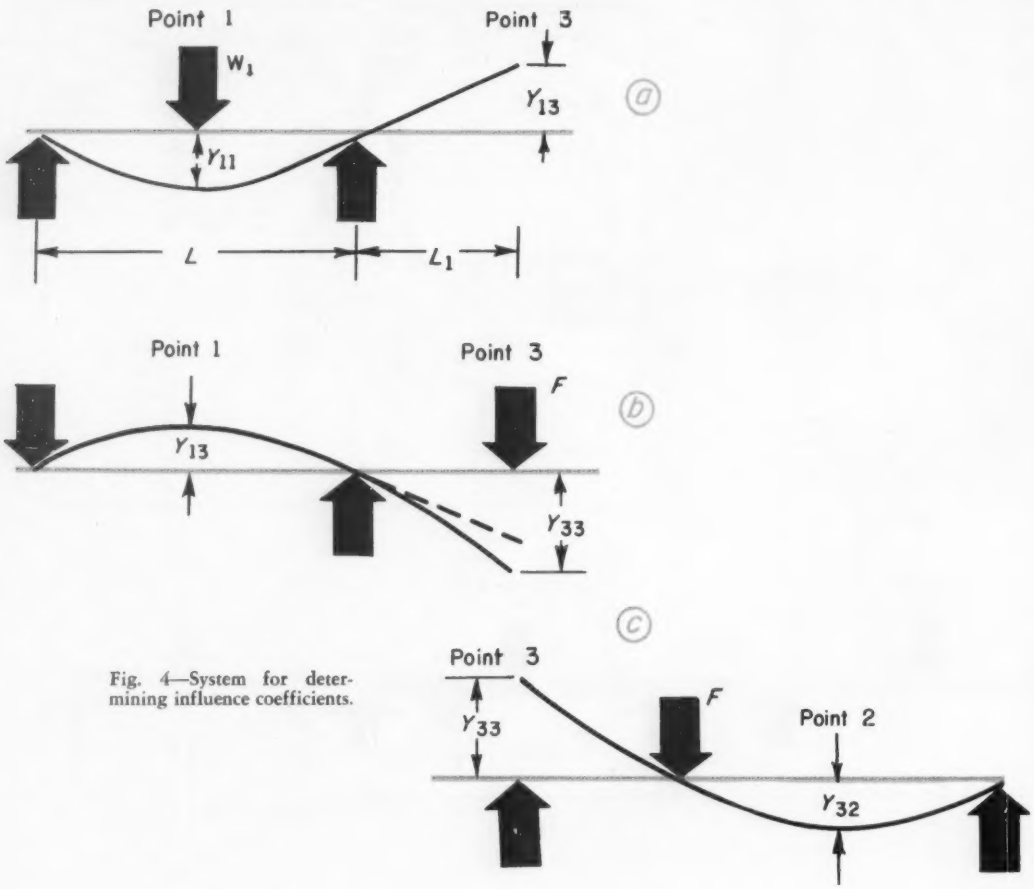


Fig. 4—System for determining influence coefficients.

average of the lengths of the original machines. Hence

$$L = \frac{24 + 14}{2} = 19 \text{ in.} \tag{8}$$

The coupling is assumed to be at the center of the middle span; thus,

$$L_1 = \frac{6 + 6}{2} = 6 \text{ in.} \tag{9}$$

The center weights are given a value that will make the single-span frequency of each machine identical with its actual value. For a single span with a center weight, the fundamental natural frequency is

$$f_n = 3.12 \left(\frac{48EI}{WL^3} \right)^{1/2} \tag{10}$$

From Equation 10, using the natural frequencies of Equations 6 and 7 [$f = \omega/(2\pi)$] the equivalent system weights are

machine A,

$$W_1 = \frac{48EI}{L^3} \frac{(3.12)^2}{f_n^2} = \frac{48(4 \times 10^6)(9.73)}{6859(3444.52)}$$

$$= 79.11 \text{ lb} \tag{11}$$

machine B,

$$W_2 = \frac{48EI}{L^3} \frac{(3.12)^2}{f_n^2} = \frac{48(4 \times 10^6)9.73}{6859(30716)}$$

$$= 8.87 \text{ lb} \tag{12}$$

A similar process is followed if the loading on the machines is distributed rather than concentrated. The goal of this initial step is to obtain a system with two identical span lengths on either side connected by a hinge in the middle of the center span. The end spans are each loaded by a single concentrated center weight.

Deflection characteristics of the equivalent system, Fig. 3, are derived by considering each load separately. Deflection in span 1 (point 1) due to W_1, Fig. 4*a*, is[4]

$$Y_{11} = \frac{W_1 L^3}{48EI} \tag{13}$$

Slope at the right-hand bearing of this span, corresponding to Y_{11}, is

$$\theta = \frac{W_1 L^2}{16EI} \tag{14}$$

Hence, deflection at the hinge (point 3) due to W_1 is

$$Y_{13} = \frac{W_1 L^2 L_1}{16EI} \tag{15}$$

For the same left-hand span, shear force at the hinge will cause deflection as indicated in Fig. 4*b*. Shear force F and lever arm L_1 create a moment, FL_1, at the right-hand reaction of span 1. This produces a deflection in the center of the span.[5] Thus, deflection at point 1 due to load at point 3 is

$$Y_{31} = \frac{FL^2 L_1}{16EI} \tag{16}$$

Corresponding slope at the right-hand reaction of span 1 is

$$\theta = \frac{FLL_1}{3EI} \tag{17}$$

and deflection Y_{33} at load F is θL_1 plus the deflection of the overhung portion considered as a cantilever. Hence, deflection at point 3 due to load at point 3 is

$$Y_{33} = \frac{FLL_1^2}{3EI} + \frac{FL_1^3}{3EI} \tag{18}$$

Shear load at the hinge also produces deflections in the right-hand span. From Equations 16 and 17, the right-hand span deflections, Fig. 4c, are

$$Y_{33} = \frac{FL_1^3}{3EI} + \frac{FLL_1^2}{3EI} \tag{19}$$

$$Y_{32} = \frac{FL^2 L_1}{16EI} \tag{20}$$

Deflection at the hinge should be the same for either the right-hand or left-hand span. Thus combining Equations 15, 18, and 19 gives

$$\frac{W_1 L^2 L_1}{16EI} = \frac{2FL_1^2}{3EI}(L_1 + L) \tag{21}$$

solving for F,

$$F = \frac{3}{32} W_1 \frac{L}{L_1} \frac{1}{1 + \frac{L_1}{L}} \tag{22}$$

The deflection at point 1 is the sum of the deflections given by Equations 13 and 16. From these equations, using Equation 22 to eliminate F,

$$Y = \frac{W_1 L^3}{48EI} - \frac{L^2 L_1}{16EI} \frac{3}{32} W_1 \frac{L}{L_1} \frac{1}{1 + \frac{L_1}{L}}$$

$$= \frac{W_1 L^3}{48EI}\left(1 - \frac{0.28125}{1 + \frac{L_1}{L}}\right) \tag{23}$$

Deflection at point 2, the middle of the right-hand span, caused by a load at point 1 is found by eliminating F from Equation 20:

$$Y = \frac{FL^2 L_1}{16EI} = \frac{L^2 L_1}{16EI} \frac{3}{32} W_1 \frac{L}{L_1} \frac{1}{1 + \frac{L_1}{L}}$$

$$= \frac{W_1 L^3}{48EI} \frac{0.28125}{1 + \frac{L_1}{L}} \tag{24}$$

Let

$$A = 1 - \frac{0.28125}{1 + \frac{L_1}{L}} \tag{25}$$

Influence coefficients are the deflections caused by unit load. Thus, deflection at point 1 caused by unit load at point 1 is

$$a_{11} = \frac{L^3}{48EI} A \tag{26}$$

and deflection at point 2 caused by a unit load at point 1 is

$$a_{12} = \frac{L^3}{48EI}(1 - A) \tag{27}$$

Since the system is symmetrical, $a_{11} = a_{22}$ and the static deflection equations are

$$Y_{1s} = W_1 a_{11} + W_2 a_{12} \tag{28}$$

$$Y_{2s} = W_1 a_{12} + W_2 a_{11} \tag{29}$$

Dynamically, if there are no losses, the equations will be similar, but weight is replaced by mass times acceleration (g). Assuming motion is harmonic

$$Y = Y_o \sin \omega t \tag{30}$$

and acceleration, d^2Y/dt^2, is

$$\frac{d^2 Y}{dt^2} = \frac{d^2}{dt^2}(Y_o \sin \omega t) = -Y_o \omega^2 \sin \omega t \tag{31}$$

Consequently, the dynamic deflection equations are

$$Y_1 = m_1 Y_1 \omega^2 a_{11} + m_2 Y_2 \omega^2 a_{12} \tag{32}$$

$$Y_2 = m_1 Y_1 \omega^2 a_{12} + m_2 Y_2 \omega^2 a_{11} \tag{33}$$

These equations can be made dimensionless by eliminating mass by use of Equation 10

$$m_1 = \frac{48EI}{L^3} \frac{1}{\omega_1^2} \tag{34}$$

Combining this with Equation 26 gives

$$m_1 a_{11} \omega^2 = \frac{\omega^2}{\omega_1^2} A \tag{35}$$

where ω_1 is the natural frequency of span 1 alone.

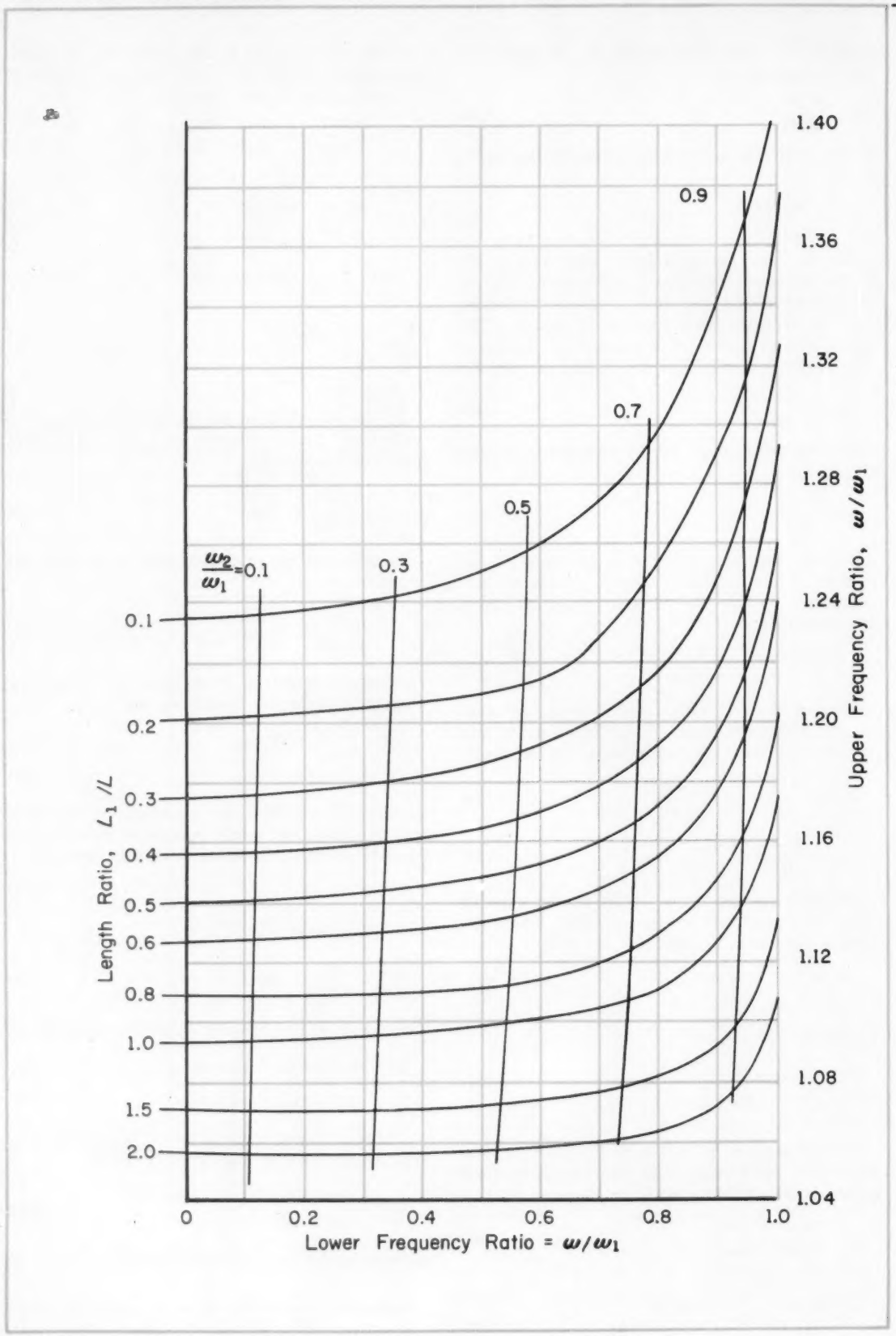


Fig. 5—Frequency ratios for hinged beam system.

In a similar fashion,

$$m_2 a_{11} \omega^2 = \frac{\omega^2}{\omega_2^2} A \tag{36}$$

$$m_1 a_{12} \omega^2 = \frac{\omega^2}{\omega_1^2} (1 - A) \tag{37}$$

$$m_2 a_{12} \omega^2 = \frac{\omega^2}{\omega_2^2} (1 - A) \tag{38}$$

where ω_2 is the natural frequency of span 2 alone.

With these substitutions, the dynamic deflection equations become

$$Y_1 = \frac{\omega^2}{\omega_1^2} A Y_1 + \frac{\omega^2}{\omega_2^2} (1 - A) Y_2 \tag{39}$$

$$Y_2 = \frac{\omega^2}{\omega_1^2} (1 - A) Y_1 + \frac{\omega^2}{\omega_2^2} A Y_2 \tag{40}$$

The natural frequency will be the value of ω that makes the denominator for the dynamic displacements zero.

This relationship can be expressed in determinant form, and solving for frequency ratio gives

$$\frac{\omega^4}{\omega_1^4} - \left[1 + \frac{\omega_2^2}{\omega_1^2} \right] \frac{\omega^2}{\omega_1^2} \frac{A}{2A - 1} + \frac{\omega_2^2}{\omega_1^2} \frac{1}{2A - 1} = 0 \tag{41}$$

This equation gives the estimated natural frequency, ω, of the coupled system in terms of the natural frequencies of the left-hand span (ω_1) and the right-hand span (ω_2).

Fig. 5 is a plot for solving this equation graphically. Since the equation is a quadratic in ω/ω_1, two system natural frequencies will be found, corresponding to a 1st and 2nd mode. The lower frequency, being the fundamental, will normally be of major interest.

Design Example: For the system of Fig. 2, the following basic data are available: $L = 19$ in., $L_1 = 6$ in., $f_1 = 58.69$ cps, and $f_2 = 175.26$ cps.

From Equation 25

$$A = 1 - \frac{0.28125}{1 + \frac{6}{19}} = 0.78625$$

Also,

$$\frac{\omega_2^2}{\omega_1^2} = \frac{f_2^2}{f_1^2} = \frac{175.26^2}{58.69^2} = 8.917$$

substitution into Equation 41 gives

$$\frac{\omega^4}{\omega_1^4} - 13.62 \frac{\omega^2}{\omega_1^2} + 15.58 = 0$$

Hence,

$$\frac{\omega^2}{\omega_1^2} = 6.81 \pm (30.80)^{1/2} = 1.26 \ , \ 12.36$$

and

$$\frac{\omega}{\omega_1} = 1.122 \ , \ 3.516$$

Thus the natural frequencies or critical speeds are estimated as

$$f = 58.69(1.122) = 65.89 \text{ cps (First mode)}$$

$$f = 58.69(3.516) = 206.33 \text{ cps (Second mode)}$$

To use the chart of Fig. 5, a slight change in procedure is required. For the example system, Fig. 2, the single-span frequencies are 58.69 and 175.26 cps.

Therefore, let $f_1 = 175.26$ cps, $f_2 = 58.69$ cps. Hence $\omega_2/\omega_1 = f_2/f_1 = 58.69/175.26 = 0.335$. Length ratio is $L_1/L = 6/19 = 0.316$. In Fig. 5, intersection of the two lines for ω_2/ω_1 and L_1/L (by interpolation) gives the frequency ratios as $\omega/\omega_1 = 0.376, 1.177$. Hence, the approximate critical speeds for the system are: $f = 0.376\ (175.26) = 65.90$ cps (first mode), and $f = 1.177\ (175.26) = 206.10$ cps (second mode).

REFERENCES

1. J. N. Macduff and R. Felgar—"Vibration Frequency Charts," MACHINE DESIGN, Vol. 29, No. 3, Feb. 7, 1957, p. 109.
2. E. H. Hull—"Effect of Foundation Stiffness on Resonant Frequency of Rotating Machines," *Journal of Applied Mechanics*, 8(3): A121-A129, Sept. 1944.
3. L. F. Spector—"Flexible Couplings," MACHINE DESIGN, Vol. 30, No. 22, Oct. 30, 1958, p.101.
4. J. N. Macduff and J. R. Curreri—*Vibration Control*, McGraw-Hill Book Co. Inc., New York, N. Y.
5. R. J. Roark—*Formulas for Stress and Strain*, McGraw-Hill Book Co. Inc., New York, N. Y.

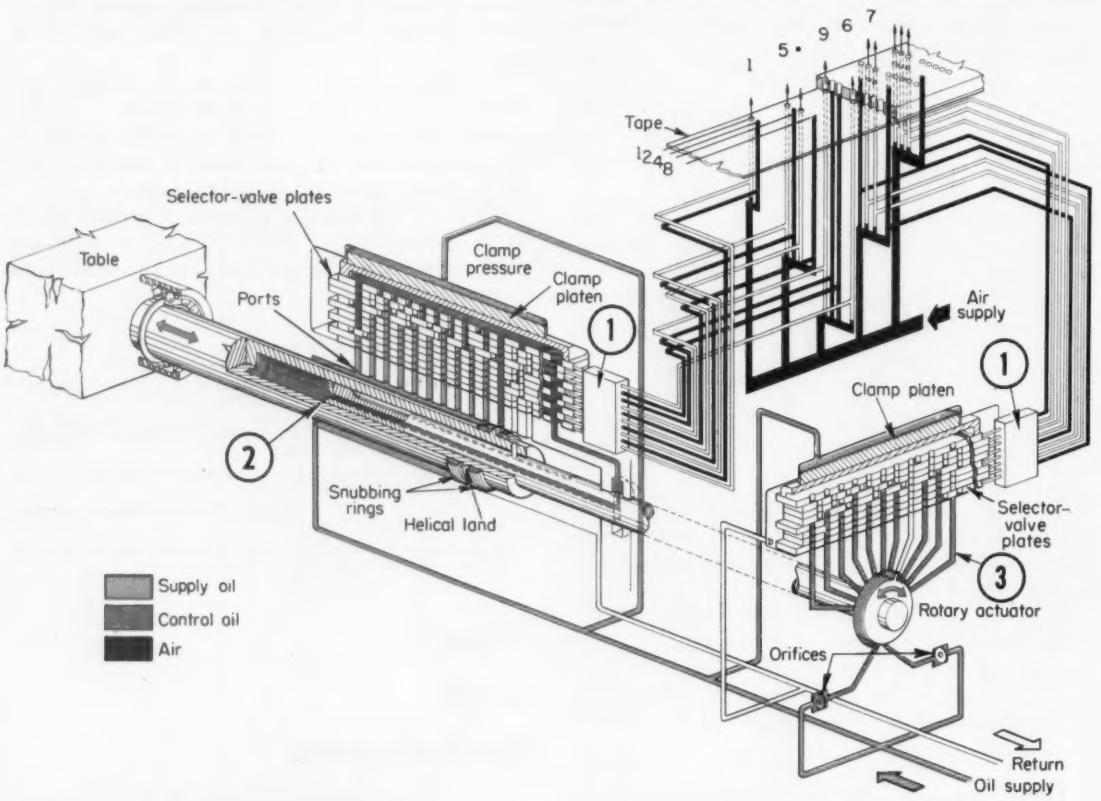
Tips and Techniques

Converting Weights

When weights given in pounds and ounces are needed in decimal form for calculations, a simple conversion may be made by using a decimal-equivalent chart. Since an ounce is 1/16 of a pound, conversion of integral numbers of ounces may be read directly from 1/16 column. For more precise conversion, weights recorded to ½ and ¼ ounce may be read from the 1/32 and 1/64 column by first multiplying by two or four, to convert the weights to a whole number in the numerator.—JOHN H. DENEEFE, *Western Gear Corp., Lynwood, Calif.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Pneumatic Tape Reader Manipulates



PUNCHED TAPE operates an air-hydraulic machine-tool control system directly without intermediate mechanical, optical, or electronic tape readers. Tape holes act as ports to relieve pressure in certain air lines, thus making a signal pattern. Signals, amplified in two hydraulic stages, position the machine tool or table directly.

Stacks of two-position sliding plates comprise the selector valves. Each combination of plate positions opens one port. Plates move in response to punched information from the tape. Hydraulic clamp holds plates together after they're in position.

Precision-spaced hydraulic ports act as encoder for the point-to-point positioning system. One set is spaced 0.10 in. apart along the actuating-cylinder wall. Position is achieved when a helical land on the piston blocks the selected port. Rotating the piston with the helical land gives intermediate positions between the 0.10-in. increments. A second set of radiating ports is spaced in 100 steps around the circumference of the piston. Operating the two sets together gives position increments of 0.001 in.

The machine tool control, called Hydra-Point, is a development of Moog Servocontrols Inc., East Aurora, New York.

Stacked Plates to Operate Machine Tool

PNEUMATIC SIGNAL pattern generated by the tape actuates selector valve plates. Release of air pressure through a tape hole relaxes the diaphragm, permits piston and selector valve to move right.

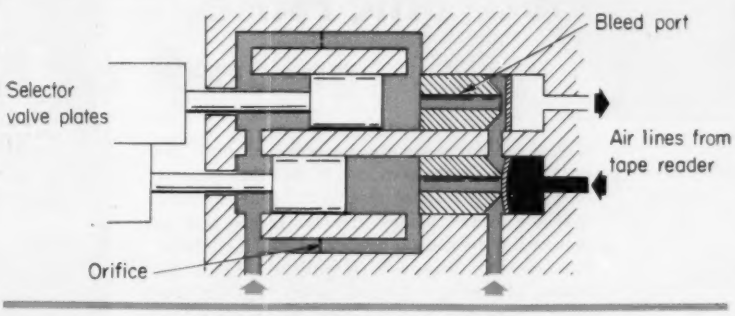
INTERNAL SURFACE of the working piston, 2A, has twice the area of the external surface, A. The piston can be in any one of three conditions:

- With the piston to the left of chosen position, the selected port opens the control volume to sump. Working pressure pushes the piston to the right.
- With the piston to the right of chosen position, the port is open to working pressure which gives twice as much force on 2A as on A. The piston moves to the left.
- With the piston exactly in the selected position, the land blocks the selected port, isolating the control volume both from working pressure and from the sump. Control pressure drops to half of working pressure to hold the piston in equilibrium.

Snubbing rings throttle control-circuit flow for gradual deceleration of the piston.

SPLINE-LIKE lands divide the annular fluid chamber into two segments. When either segment is opened to sump pressure through a selector-valve port; resulting flow develops a pressure drop across a supply orifice. Difference in pressure between segments moves the land toward the open port until escaping fluid is blocked and pressure equilibrium between segments is established.

1



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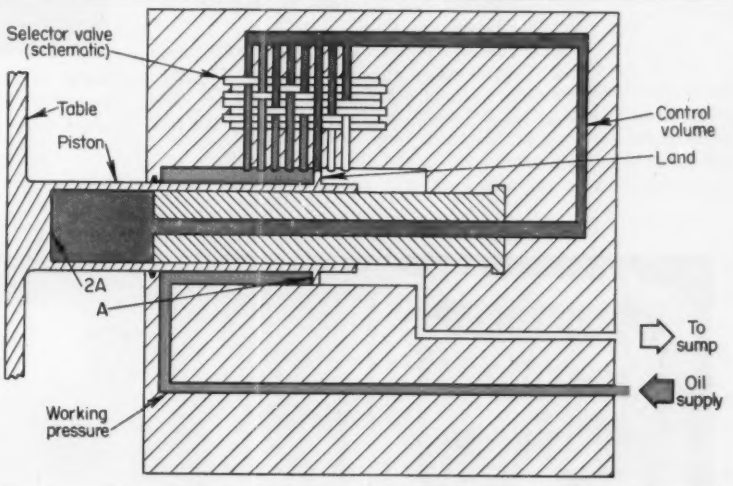

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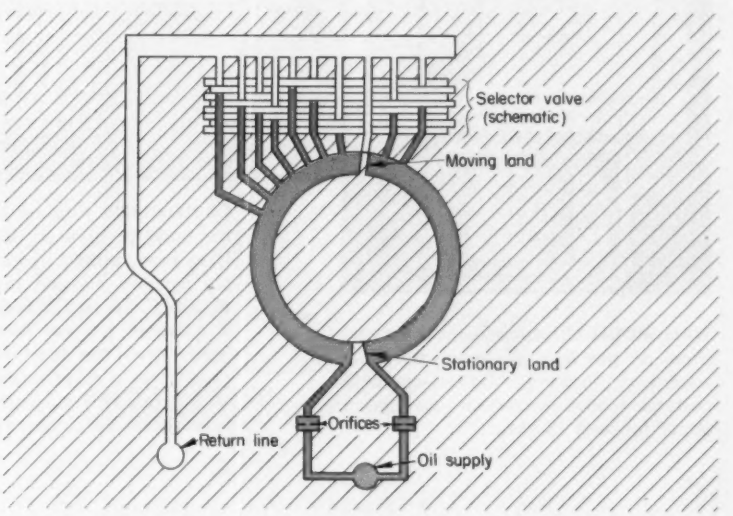
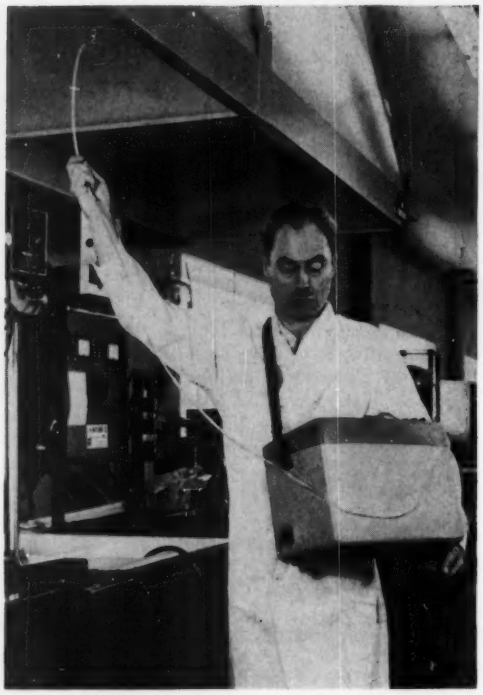
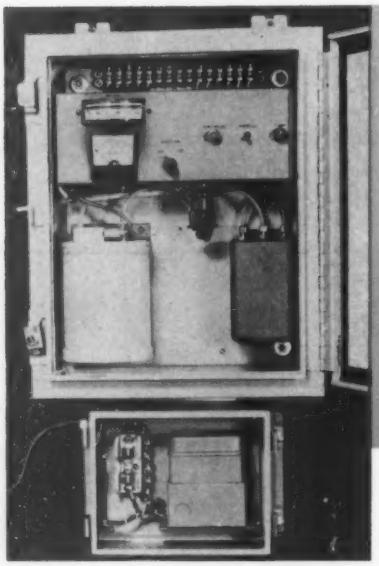


Controlled Electrolysis Operates Electronic Nose

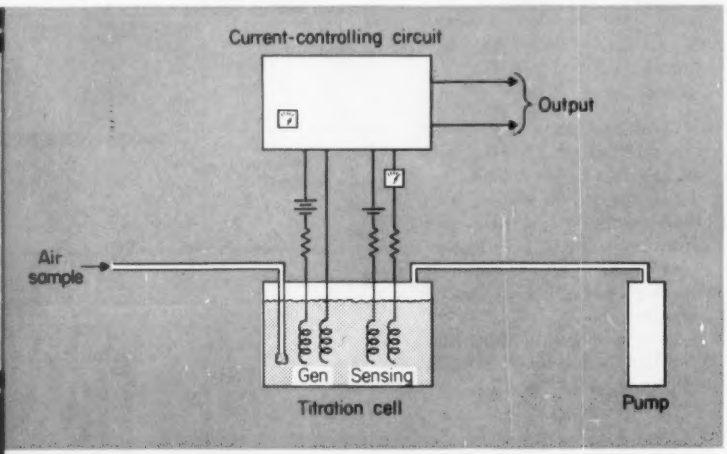


MACHINES THAT SIMULATE the sense of smell use electrochemical reactions to record the presence of minute quantities of toxic gases. The electronic sniffers are more limited than the human nose in that each is designed to detect a particular chemical. However, they respond to as little as 0.5 parts per million of a foreign chemical in air. Called Olfactrons, the devices were developed by American Systems Inc., Hawthorne, Calif.

Rocket fuel is detected by the model 4070 Olfactron. Unsymmetrical dimethyl hydrazine (UDMH) is toxic at levels of concentration lower than what would cause an explosion. With tons of the fuel being handled in space programs, a means was needed to discover when personnel had been exposed to it, plus length and level of exposure.

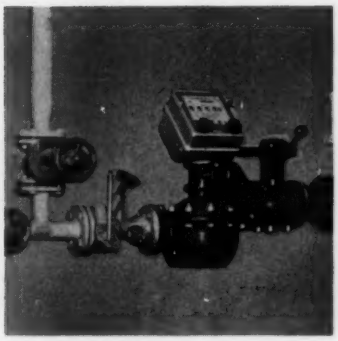


WALL-MODEL Olfactron keeps a running check on the level of fuel vapor in a hazardous location. Battery-operated portable model (above) can be carried about for spot checks.



COULOMETRIC titration is controlled by a servo circuit to sense the presence of toxic UDMH fuel. Generating circuit (left) analyzes bromide into hydrogen and bromine. Fuel in the air sample entering the unit reacts with the bromine, taking it out of solution. Sensing circuit (right) has a small voltage applied to it. Current will not flow unless bromine is present in the solution. When the level falls below a pre-set value, the sensing circuit trips a relay to close the generating circuit. Current level in the generating circuit, as shown on the meter, is a direct function of the concentration of fuel vapor in the air sample.

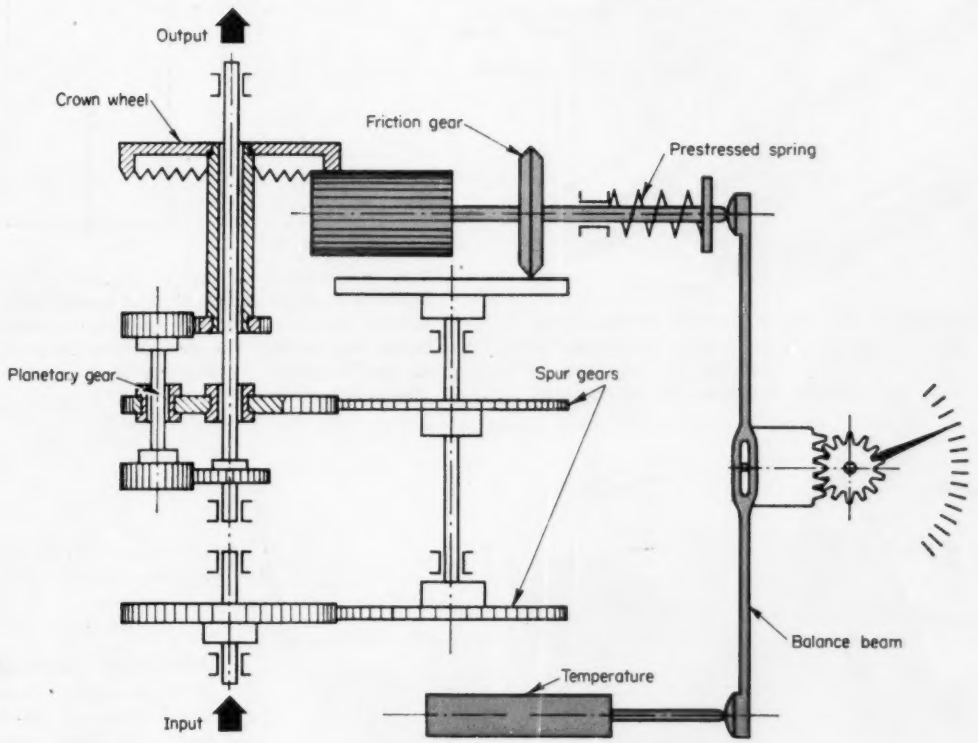
Temperature Sensor and Mechanical Integrator Correct Flowmeter Reading

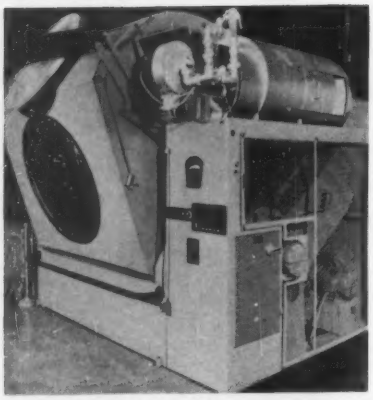


FLOWMETER with temperature compensation was designed by Siemens & Halshe AG, Munich, Germany.

WHEEL-ON-DISC integrator responds to fluctuations of a temperature sensor to change the output rate of a flowmeter. The adjusted readings reflect thermal expansion and contraction of the gas. Output readings can be calibrated directly in meaningful terms like weight, Btu content, or reaction potential.

EXPANSION AND CONTRACTION of temperature sensor move a balance beam that positions the spring-loaded integrating wheel. The balance beam is geared to a pointer which gives an instantaneous reading of temperature conditions in the line. Output is picked from the integrator by a crown wheel.

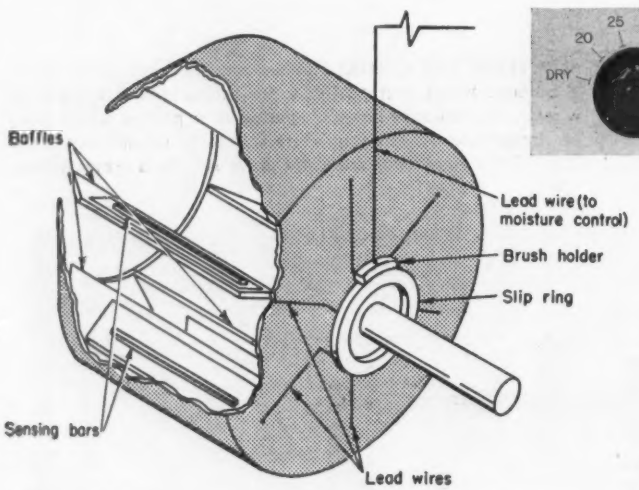




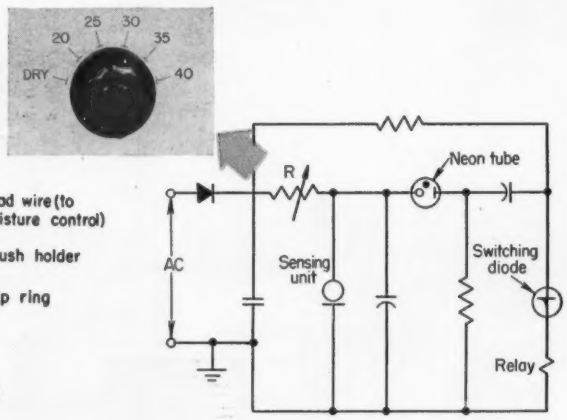
DIRECT-SENSING moisture-content regulator was developed by Controls Co. of America, Schiller Park, Ill. It's used in a T. L. Smith commercial-laundry dryer. Controls Co. says the regulator is ready for use in home laundry units.

Moisture-Content Sensor Controls Clothes Dryer

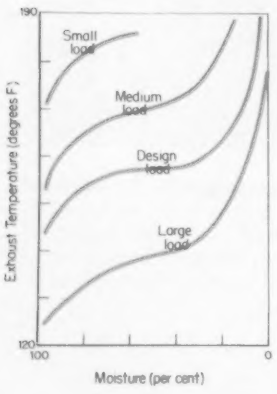
EXACT moisture content can be specified within narrow limits for clothes coming out of a new laundry dryer. Drying cycle is shut off by a control which senses water content of clothes directly rather than elapsed time or exhaust temperature rise. It's done with a unit that senses change in electrical resistance as the clothes dry. This function is not dependent upon environmental conditions nor upon the size of the load—factors that have made previous controls somewhat erratic in their results.

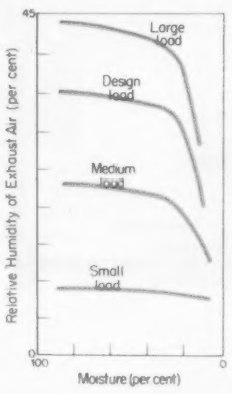


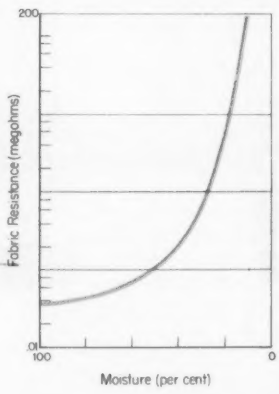
SENSING elements are mounted on internal baffles of drying drum. They are brass bars that carry a charge to test resistance of the dryer load. If baffles are not plastic or similar nonconducting material, the bars must be insulated.



DIAL calibrated in per cent of moisture content operates variable resistance R to control firing point of the neon tube. As resistance increases across the sensing unit, charge is accumulated to fire the tube. A switching diode operates the control circuit.



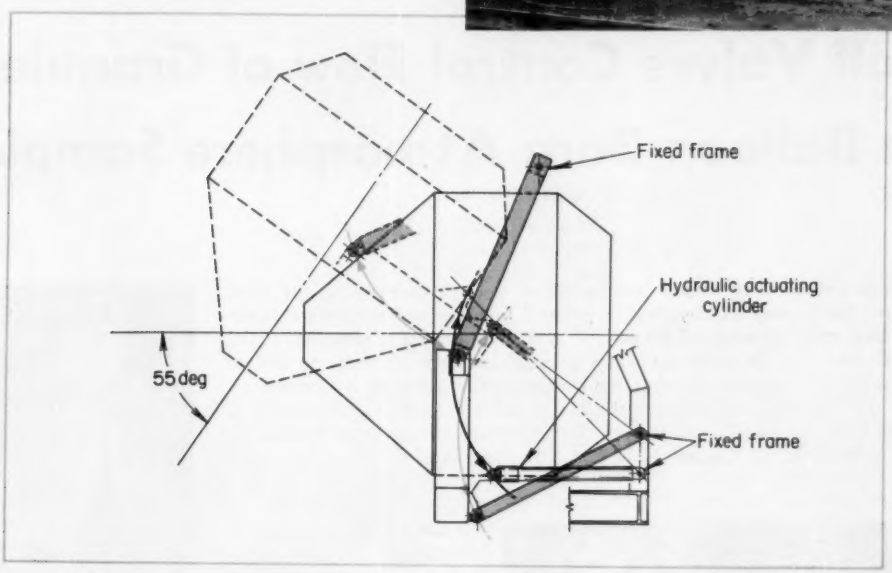




RESISTANCE SENSING gives a single curve (right) over a wide range of other variables. External parameters can shift values found by other sensing methods.

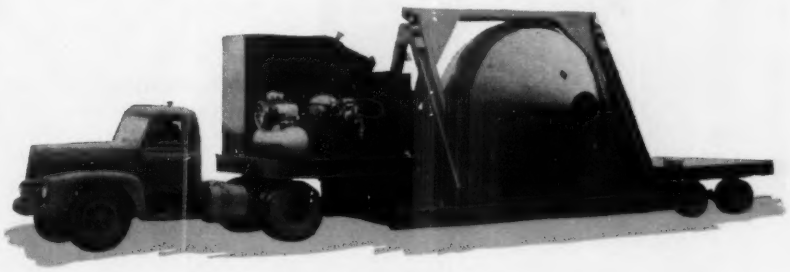
Piston-Driven Four-Bar Linkage Dumps Cement Mixer

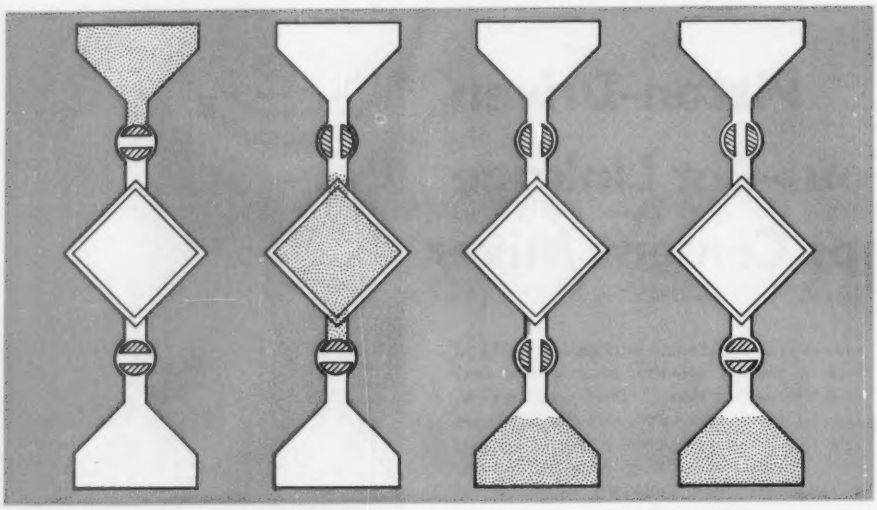
INSTEAD of tilting directly to discharge its 7½-yd load, a portable concrete mixer swings away from its base as it dumps. Besides solving clearing problems with the stationary charging chute, this motion pours low-slump slurries directly into the center of the receiving truck. Spillage is minimized. A hydraulically driven linkage defines the path of motion.



DUMPING MOTION is controlled by two oscillating links attached to the frame. Piston extends to dump the load. Forward motion of the mixing drum moves the rear clear of the loading chute as it tilts up. Discharge falls safely into the center of the truck. Previous mixers were loaded by a chute that moved out during dump.

MOBILE MIXER is mounted on a trailer body with a dropped center section for increased head clearance. For highway travel the unit is 36 ft long by 11 ft wide by 13½ ft high. At the work site the trailer, properly jacked and blocked, becomes the work platform for the mixer. It is built by the Erie Strayer Co., Erie, Pa.

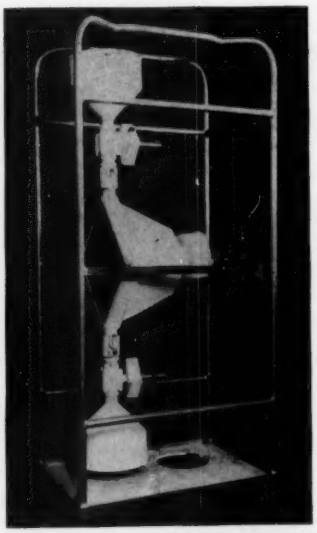


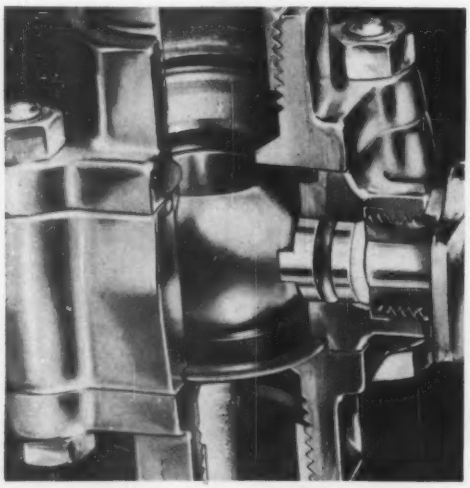


Ball Valves Control Flow of Granules In Balloon-Born Atmosphere Sampler

GRANULES of a chemical are carried aloft by balloon to check the nature of the upper atmosphere. On the way up, they must be protected from any environment that might alter the final indicated results of the test. They must be exposed as prescribed at the test altitude and then be stored again in a protected container for return to ground.

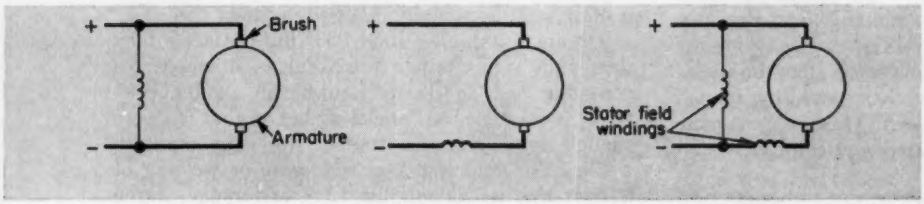
To handle this sequence of events two canisters are separated by a filtered compartment that's exposed to environmental air. Ball valves are opened and closed by a servomotor to let the granules pass through the system. The balloon-borne air-sampling device was developed by General Mills Corp., Minneapolis.





BALL VALVES are chosen because they combine the large unobstructed passage necessary for the easy flow of solid granules, and the tight seal necessary to maintain vacuum at 2 psia in the canisters. The valves are made by the Worcester Valve Co., Worcester, Mass.

UPPER CANISTER CONTAINS granules used in the test. They're in an atmosphere of 2 psia dry nitrogen used to purge all ground-level impurities that might influence the test. At the chosen altitude, the upper valve is automatically opened, letting the granules fall into the indicator chamber (center). After the exposure period, the lower valve is opened and granules fall into the lower canister where they're sealed for their journey back to earth.

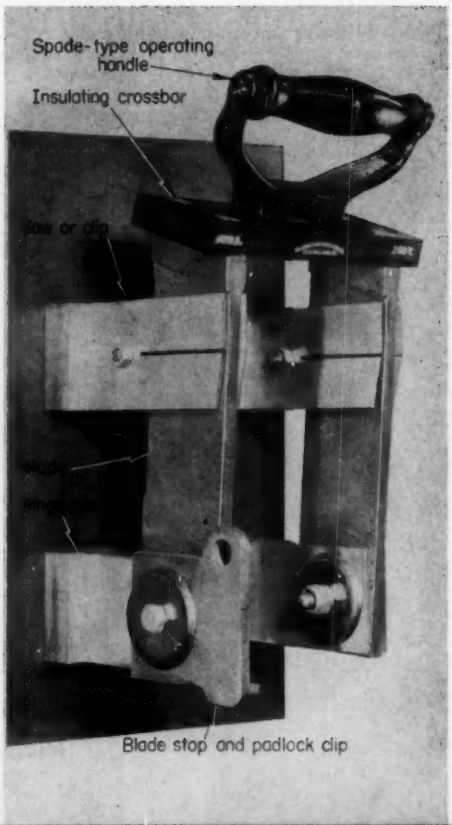


DC Motor Control

Part 3—Basic Controller Hardware

. . . what the devices are, and how they operate

J. RONALD WICKEY
Staff Engineer
The Clark Controller Co.
Cleveland, Ohio



COMPONENTS which make up a controller can be classified into three basic groups: 1. Disconnect switches. 2. Contactors. 3. Relays. Although other items, such as brakes, rheostats, and pilot devices, are required for a complete control system, these are not usually mounted on the controller.

Electrical connections and functions of the basic controls have been discussed.[2] Featured here are the physical construction and mechanical operation of these devices.

• Disconnects

A device for removing the source of power from the controller is a disconnect. In most dc controllers, usual practice is to use a simple knife switch, Fig. 1, which can be either fused or unfused, depending upon its use. Unfused switches are generally used for power circuits on dc controllers, while fused switches are commonly used in control circuits.

Other variations of the basic knife switch are

[2]References are tabulated at end of article.

Fig. 1—A two-pole type of knife switch commonly used as a disconnect device on dc controllers.

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sometimes used. One example is the "dead-front" knife switch which is so constructed that the blades and jaws are not exposed to the operator's hand.

Circuit breakers are occasionally used for disconnect devices on dc controllers, especially for the control circuit, and in some cases for the field-circuit disconnect means. Another possibility, though rarely used, is the safety switch. This device is more commonly applied in ac starters and control.

• Contactors

As defined by NEMA, a contactor is a device which repeatedly establishes and interrupts an electric-power circuit; and a magnetic contactor is a contactor which is actuated by electromagnetic means. NEMA lists standard sizes of dc contactors on the basis of both size numbers and corresponding ratings in amperes. Sizes range from Size 1 through 9 with corresponding ampere ratings from 25 to 2500 amp.

Contactors are also rated in horsepower, since they usually are component devices of starters or controllers. These NEMA power ratings are given for various voltages and for different types of controllers. A typical dc contactor is shown in Fig. 2.

Although power ratings are often considered continuous in current-carrying capacity, this is not the case. NEMA specifically states that these are 8-hr ratings and thus require that the contactor be opened at least once in every 8-hr cycle. Because contact tips of dc contactors are almost always made of copper, copper oxide forms at the junction of the surfaces of the movable and stationary contact tips. Copper oxide resists the flow of electricity and will cause additional heat to be generated at the junction. If permitted to continue, this process can result in excessive temperature rise at the contact tips.

However, if the contactor is operated soon enough, the mechanical roll or wipe of the contact tips as they open and close tends to remove any copper oxide that may be forming. Thus, occasional operation essentially prevents a build-up of copper oxide.

When applications require that dc contactors be closed and carry current for an indefinite period of time, contact tips of silver or silver alloy should be specified. Although silver oxide may tend to form, it is a good conductor of electricity. Silver contacts are not provided as a standard feature on contactors because of high original cost, tendency to weld from high-current arcing, and comparatively short life.

Contactors are also designed to meet a range of operating voltage which might be applied to the coil of the contactor. According to NEMA standards, direct-current contactors must withstand 110 per cent of their rated voltage continuously without injury to the operating coils and they must close successfully at 80 per cent of their rated voltage.

Thus, a contactor nominally rated at 230 v must operate satisfactorily on any line voltage between 184 and 253 v. A voltage lower than 184 may not provide proper closing operation. Not only may the contactor be sluggish in operation, but also it may not seal properly. This can cause excessive heating, and even welding, of the contact tips.

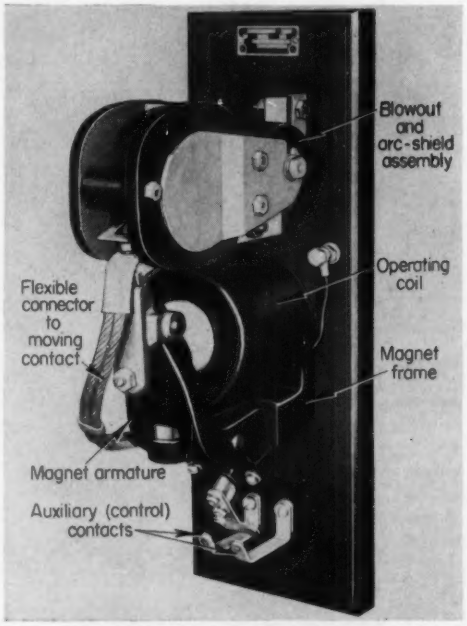
If voltage is higher than 253, the contactor may slam unduly in closing. As a result of this excessive pounding and shock, mechanical life of the contactor is shortened. Also, closing action that is severe enough to bounce the contact tips can cause tip welding. Therefore, if excessive wear or welding of contact tips is evident, the level and range of the voltage across the operating coil should be checked. Occasionally, specially wound coils are required to alleviate the condition.

Because the power circuit of a dc motor has appreciable inductance, interrupting the power to a motor can cause severe arcing at the tips of the contactors. Therefore, it is standard practice to equip dc contactors with a blowout device which minimizes or suppresses the arc.

• Relays

NEMA defines a relay as a device which is operative by a variation in the conditions of one electric circuit to effect the operation of other devices in the same or another electric circuit. Further, a magnetic control relay is a relay which is actuated by electromagnetic means. When not otherwise qualified, a magnetic control relay is intended to be operated by the opening and closing of its coil circuit and has its contacts designed for energizing and/or de-energizing the coils of magnetic contactors or other magnetically operated devices.

Fig. 2—Mill-type contactor, 300-amp rating, NEMA Size 5, for use in armature (power) circuits of dc controllers. Other NEMA sizes are similar in appearance.



Obviously, these NEMA definitions are rather broad, but they must be since there are many types and applications of relays. Perhaps a simpler distinction is that general-use relays are used in control circuitry for interlocking, sequencing, and initiating operations, and that specific-function relays are essentially each designed and used for a specific function. More importantly, relays should be differentiated from contactors—relay contacts function in coil circuits of other relays or devices and not in a motor armature or other type of power circuit.

Although the circuits controlled by the contacts of relays usually carry inductive loads, currents are usually less than 1 amp. Therefore, a basic general-use relay does not require a blowout. However, when large contactor coils, or a number of coils, are handled by the contacts of a relay, a blowout may be needed. Relays are available with this feature, Fig. 3a.

Arcing can be reduced by using multiple-break contacts. For this reason, relays which give a double break on each contact, Fig. 3, are commonly specified. However, using more than one pole in series in a given circuit is sometimes an advantage even though each pole is the double-break type.

NEMA does not specify current ratings for, or different sizes of, dc control relays. Specific standards are not necessary since these relays handle only a nominal amount of current. Most relays are specified as being capable of carrying 10 or 15 amp without overheating the contact tips.

However, since relay contacts are most often used in inductive circuits, their ability to interrupt these circuits without undue arcing at the tips is important. Unfortunately, this characteristic is not easy to define and rate. In the few cases where inductive-circuit-interrupting capacity of relays is given, the rating is nominal and usually surprisingly small—in the order of 1 or 2 amp, or even less.

Specific-purpose relays are available in many different types, sizes, and shapes. In general, the name given to the relay defines its specific use. These relays can be further segregated into three more or less distinct groups: 1. Overload relays. 2. Timing relays. 3. Miscellaneous specific-purpose relays.

Some of the specific-purpose relays are inherently designed to perform one function only and can seldom be modified or varied for other applications. However, most can be adapted for a variety of possible uses by selection of coils and adjustment of the relay.

Inherently, most of these relays are either current or voltage sensitive and have either a normally open or normally closed contact. Also, their magnetic structure is so designed that different basic relays have a different relationship between the flux necessary to operate the relay and the reduced flux at which the relay drops out. This characteristic is the operating differential of each general type of relay.

Overload Relays: The function of an overload relay is to provide protection against an overload current—that is, a too-high current—which could cause damage to the motor, the controller, or both. Although the relay cannot prevent the occurrence of such a condition, it senses when the condition exists and operates other devices which disconnect power from the controller and motor system, normally, by dropping out the contactors in the power circuit.

To provide the necessary protection, it is desirable that the one or more overload relays function to differentiate between:

1. Normal running loads which must be allowed to continue.

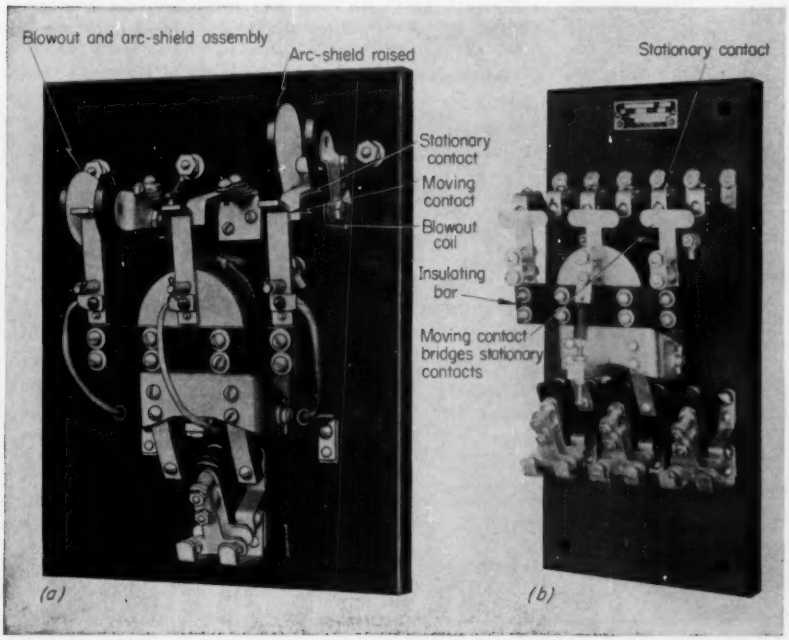


Fig. 3—Typical dc control relays for operating, sequencing, and general-use purposes. Relay in *a* has lower set of double-break contacts and upper set of single-break contacts with blowouts. All contacts for relay in *b* are double break.

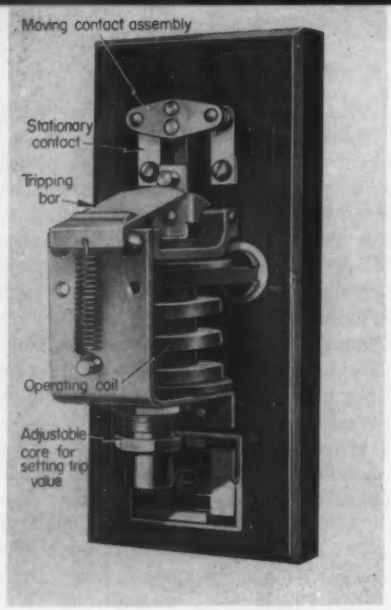


Fig. 4—Inverse-time overload relay with cover omitted. Instantaneous-trip type of overload relay is similar in appearance.

2. Slight overloads which should be removed after a comparatively long time.
3. Moderately heavy overloads which should be removed after a comparatively short time.
4. Extremely heavy overloads—those approaching a short circuit—which should be removed as quickly as possible.

Seldom can all these features be obtained in a single relay. Therefore, two overload relays, the inverse-time type, Fig. 4, and the instantaneous type, are usually provided. The only difference between the two types, in the design shown, is the core, which is the main part of the magnetic structure.

The typical setting of the inverse-time overload relay is approximately 125 per cent of full-load current of the motor. If this amount of current is allowed to pass through the relay for an indefinite period, the relay will eventually trip. As the amount of current flowing through the relay coil becomes larger, the relay will trip in shorter time. The relay has a "break off" point in the inverse-time curve at which it will trip instantaneously at about 400 per cent of full-load motor current.

In the instantaneous type of relay the core is a solid piece of steel. The operating characteristic is such that the relay will not trip, regardless of the length of time, until the current reaches a value determined by the setting of the relay core. At that value the relay will trip instantaneously. A typical setting is approximately 300 per cent of full-load motor current.

Timing Relays: In one type of timing relay, when the coil is energized, the relay operates after a predetermined elapsed time, Fig. 5. In a second type, when the coil is de-energized, the relay drops out, or resets, after a time delay. By proper selection of normally open or normally closed contacts for one or both these types of relays, almost any desired result can be obtained.

Timing relays are usually so constructed that the time-delay interval is adjustable. The type in Fig. 5, with a given core assembly, is adjustable over a nominal range of 3 to 1, and if different cores are substituted, various nominal ranges are available.

Field-Loss Relay: If the shunt-field circuit is opened or broken so that there is a loss of field excitation, the motor can reach a dangerous overspeed condition. A field-loss relay, Fig. 6, senses that such a condition exists and removes power from the motor by dropping out the power-circuit contactors.

The relay has a normally open contact. The relay coil is connected in series with the shunt field of the motor. Therefore, when current is flowing through the shunt field and the relay coil, the relay is energized and closed. If the shunt-field circuit

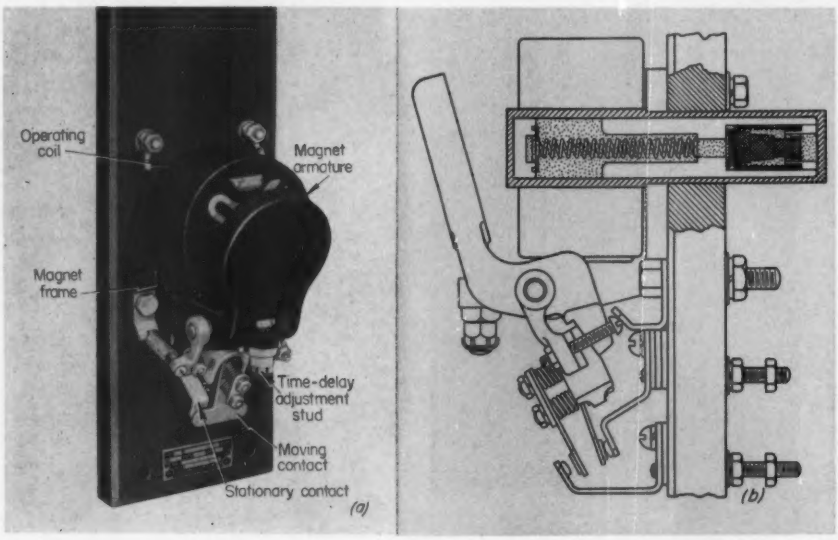


Fig. 5—Typical timing relay with adjustment for delaying contact action after coil is energized. Time delay is produced by a special core which is part of the magnetic structure. Relay in *a* has normally closed double-break contact; sketch, *b*, shows the internal parts of the time-delay core.

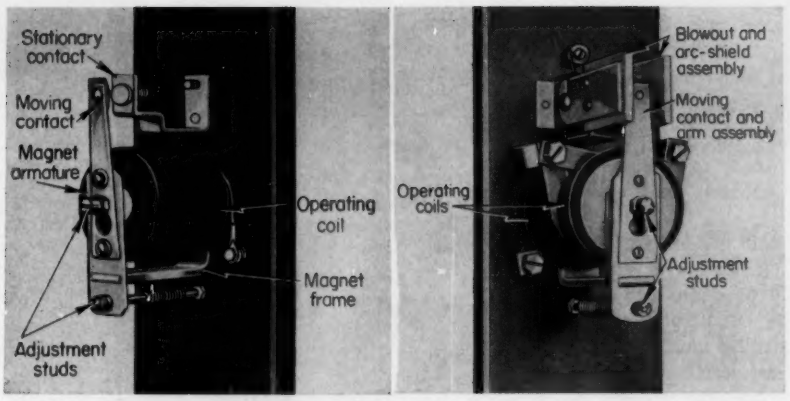


Fig. 6—Extreme left—Field-loss relay for providing protection against an open condition in the shunt-field circuit.

Fig. 7—Left—Double-coil type of field accelerating relay for controlling shunt-field excitation during motor acceleration.

is opened, the relay is de-energized, and its contact opens to signal the controller to remove power from the motor.

Since field currents vary widely for different ratings and sizes of motors, field data for a particular motor is necessary to insure proper selection of a relay coil. However, relays are designed to operate over a wide range of coil currents, even with a given coil. This prevents false operation of the relay as a result of field-rheostat setting or manipulation.

When a motor is started from rest, the inrush current flowing through any series-type field winding tends to induce a transient voltage in the shunt-field winding. This voltage opposes the polarity of the supply voltage and therefore momentarily reduces the flow of current in the shunt field. This reaction is commonly referred to as the tendency of a compound wound motor to "blow out" the shunt field at starting.

For a motor which has medium to heavy compounding, shunt-field current may be reduced to such a low value that the field-loss relay drops out and removes the motor from the power supply. To prevent this type of false operation, a relay which has a slight time delay before it drops out after de-energization is used. A brass sleeve around the main core provides a short time delay of about $\frac{1}{4}$ sec. This delay, although short, is generally satisfactory since the transient loss of field exists only for a short time.

However, for heavily compounded motors, the transient effect is more severe and lasts longer. In such cases, the condition will not always be within the limits of a relay designed for normal use. A remedy can usually be effected within the circuitry of the controller by bypassing the contacts of the field-loss relay with the contacts of some other device, such as an accelerating contactor. As a result, the field-loss relay has no effect for a short time. During this period, the transient condition disappears. In most cases where a heavily compounded motor is used, however, a field-loss relay is not necessary and may be a misapplication.

If a motor has a heavy series field, it is not likely to overspeed dangerously even if the shunt-field circuit is broken. If, at the same instant, the load on the motor is lost or falls to a low value because of a mechanical fault, then the field-loss relay would have appreciable protective value. However, such a simultaneous happening of two unrelated faults is extremely unlikely and in most cases can be ignored.

Another type of field-loss relay does not have a built-in time-delay but drops out immediately upon de-energization of its coil. This relay is suitable for use with a shunt motor or a motor which has little series winding since there is little or no tendency for the shunt-field current to be blown out.

Field Accelerating Relay: When the speed of a dc motor is adjustable over a range of approximately 2 to 1 or higher by means of a rheostat or resistor in the shunt-field circuit, two undesirable conditions can arise: 1. When accelerating from standstill to base speed. 2. When accelerating to some desired speed above base speed.

During acceleration from standstill, the shunt field should be at full strength. If the field is weak, motor torque is low, and the motor may not develop enough torque to accelerate at all. Strength of the shunt field can be kept at maximum, that is, at base speed condition, by having contacts short out the field rheostat or resistor until the motor has reached, or nearly reached, base speed. Contacts, or a relay operated from contacts, on the last accelerating contactor could be used for this purpose.

When accelerating above base speed, field strength must be weakened. With the motor running at base speed, the rheostat is at its all-resistance-out position. If resistance is quickly inserted into the shunt-field circuit, field flux is suddenly weakened. The motor, in its attempt to maintain torque and increase speed, will require a higher armature current. This current may become great enough to operate the overloads and thus remove the motor from the power source.

The solution to this second undesirable condition is to weaken the field in steps. This is usually difficult to do, but a satisfactory result is obtained if the field is weakened, then strengthened momentarily, then reweakened, and so on. Thus, the motor is given a series of short-time "pushes" up to the speed determined by the field-rheostat position with-

out allowing severe armature-current peaks.

Some methods of accomplishing this dual-purpose function may require two separate relays or one relay plus additional auxiliary contacts on the last accelerating contactor.

One relay, Fig. 7, has two coils which are connected in series, or, in effect, one coil with an intermediate tap, and a normally open contact. The coils are connected in the power circuit of the controller and both carry current during motor acceleration to base speed. When the last accelerator closes, one coil is bypassed, but the other coil remains in series with the motor armature.

Until the last accelerating contactor closes, the relay is held closed by the current flowing through both its coils. The relay contact is connected across the rheostat and shorts it out when the relay is closed. Therefore, the motor accelerates to base speed with full field strength.

The relay is designed and the coils are selected so that, with both coils in the circuit, the relay will operate and remain operated on an armature current as low as 50 per cent of full-load current. This insures that the relay will not drop out during acceleration even if the current drops as it could with a lightly loaded motor.

When the last accelerating contactor closes, only the one coil remains in the circuit. The strength of this coil and the relay adjustment are such that the relay will close if the current is approximately 125 per cent of full-load current. In Fig. 7, this coil is located next to the magnet armature.

Therefore, if the rheostat is rapidly moved to the all-resistance-in position, the surge of armature current may be great enough to operate the relay, close its contact, and short out the field rheostat. But until the rheostat is shorted out, motor speed increases appreciably.

When the rheostat is shorted out, armature current begins to fall. The relay is so adjusted that, when the current falls to about 105 per cent of the full-load value, the relay drops out and reinserts the field rheostat. This results in another surge of current, and the cycle is repeated. Because of this cyclic closing and opening operation, this type of relay is sometimes called a field-fluttering or field-vibrating relay.

If the speed range of a dc motor is less than about 2 to 1, neither the loss of starting torque nor the current-inrush peaks as speed increases are important enough, usually, to require the use of a field accelerating relay.

Field Decelerating Relay: When a dc motor is operated over a speed range of approximately 2 to 1 or higher by adjusting resistance in the shunt-field circuit, an undesirable condition can arise in decelerating from maximum speed to base speed. At maximum motor speed the field rheostat is in its all-resistance-in position. If resistance is quickly removed from the shunt-field circuit, the field and

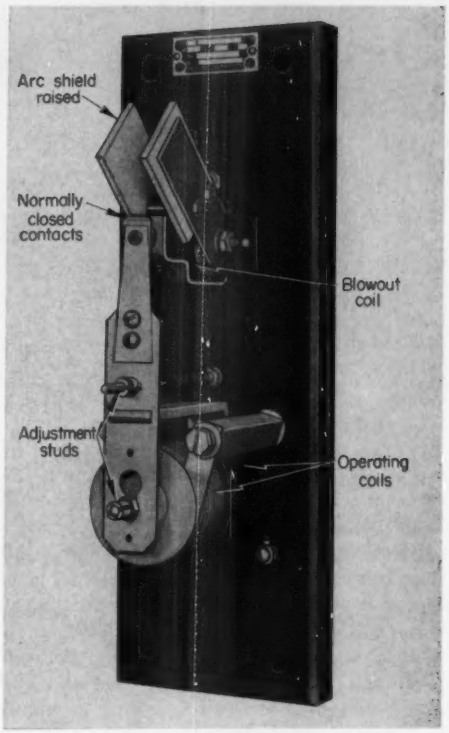


Fig. 8—Field decelerating relay with series and shunt coils for controlling shunt-field excitation during motor deceleration to base speed.

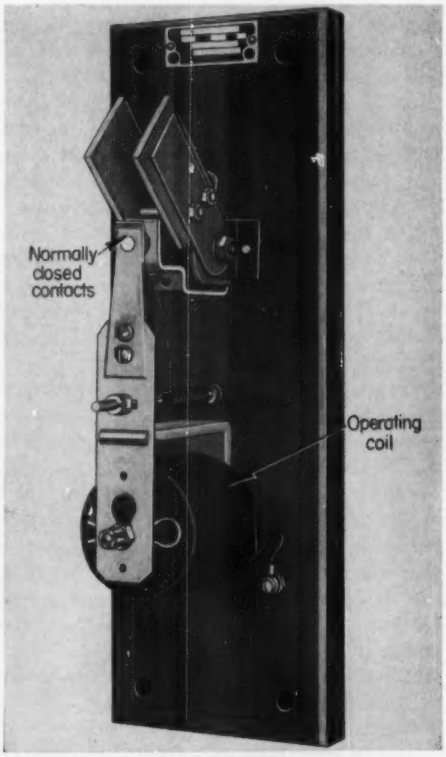


Fig. 9—Antiplugging relay with voltage-sensing coil for preventing plug-reversal or plug-to-stop operation of a motor.

field flux are suddenly strengthened, and the counter-emf generated internally by the motor will rise rapidly. If the counter-emf becomes greater than the voltage of the power supply, current flow through the motor armature will reverse. This reverse current may reach an undesirably high value.

A field decelerating relay senses this reverse current and initiates action to limit its magnitude. A typical design, Fig. 8, has a series coil connected in the power circuit of the controller and a shunt coil connected across the control circuit. These coils are so polarized and proportioned that the relay will not operate on armature current flowing in the normal direction, but the relay will operate when armature current is reversed and exceeds a safe value. The relay has a normally closed contact.

A resistor which is connected in series with the motor shunt field is also required. This resistor is

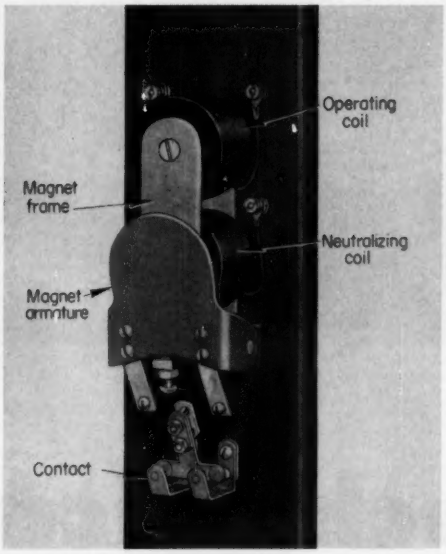


Fig. 10—Self-contained plugging relay which allows and controls plug-reversal or plug-to-stop operation of the motor.

shorted out by the normally closed relay contact. When the relay operates, its contact opens and inserts the resistor into the field circuit. However, before the relay operates, motor speed is appreciably decreased by the reverse current.

When the resistor is inserted, counter-emf and, therefore, reverse current, begin to fall. When this current is reduced to another predetermined value, the relay drops out, and the cycle is repeated. This fluttering relay operation is similar to that discussed for the field accelerating relay.

If the speed range of the motor is less than about 2 to 1, usually the reverse current will not become high enough to require the use of a field decelerating relay. Also, it is usually rather difficult physically to move the rheostat over its full travel fast enough to cause the reverse current to reach a high value. Therefore, although this relay has a definite place in controller application, it is used only occasionally.

Antiplugging Relay: A nonplugging or antiplugging controller is one of the two basic types of reversing controllers in which some means is desired for preventing the closing of the opposite-direction contactors until the motor is approximately at rest. This type of operation can be accomplished with an antiplug relay, Fig. 9. This relay has a shunt-type coil and a normally closed contact.

In conventional use, the relay coil is connected across the motor armature and therefore measures the magnitude of the motor counter-emf. The normally closed contact is connected in the circuit containing the operating coils of the reversing contactors.

The relay operates and opens its contact when the voltage across its coil indicates that the motor is running at appreciable speed. The relay remains operated until the voltage across its coil drops low enough to indicate that the motor has slowed almost to a standstill.

Plugging Relay: The second basic type of reversing controller applies a voltage of reverse polarity to the armature. This results in a "power retardation" of the motor because the flow of current through the armature is also reversed. After the motor has slowed to a standstill, it accelerates in the opposite direction. This method of retardation and reversal is incorporated in a reversing-plugging controller.

During the plugging cycle and until the motor has stopped, the counter-emf of the motor has the same polarity as the power-supply voltage. Therefore, the total of these two voltages appears across the accelerating resistor. To prevent an objectionably high current from flowing through the resistor and the motor armature, an additional amount of resistance is inserted during the plugging cycle. This resistance is removed when the motor has approximately reached standstill to permit normal acceleration in the opposite direction.

Thus, the plugging system requires an additional resistor, a plugging contactor to insert or remove the resistor, and a signal which insures that the contactor can operate at, and only at, the proper time. The most important unit of this system is the plugging relay which senses motor speed and signals the plugging contactor. This relay could perhaps be described as a "plugging control" relay.

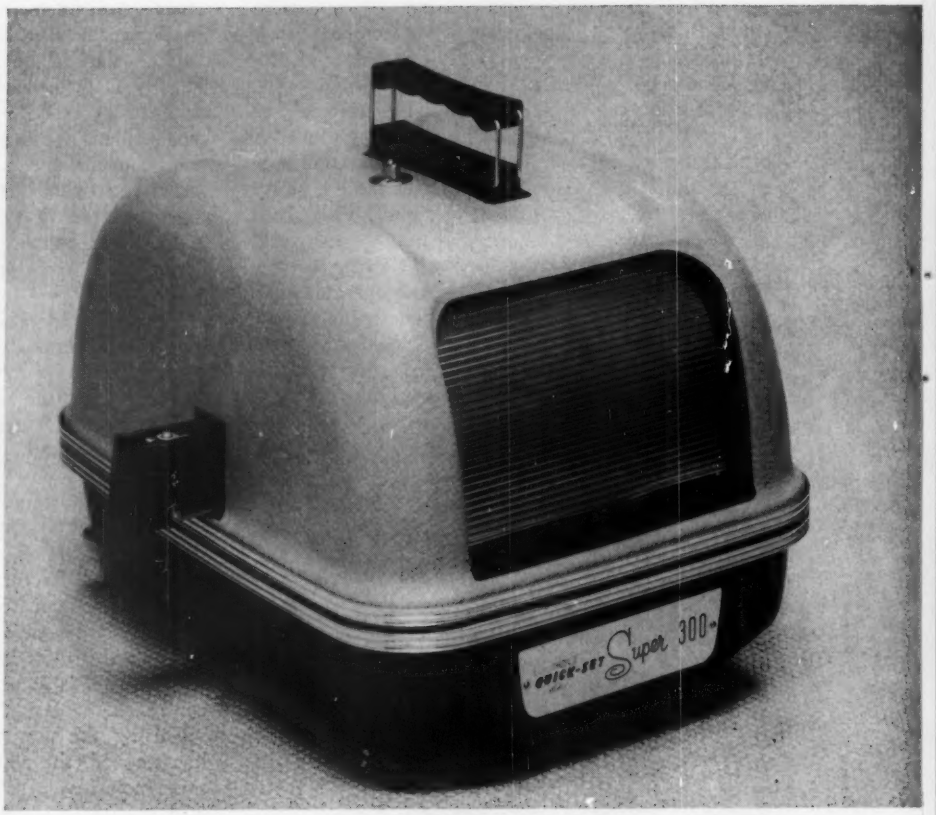
Some methods for obtaining the control signal require two relays and often additional devices, such as one or more rectifier-type valves. One relay which meets all the requirements for control of the plugging system is shown in Fig. 10.

Next article in this series will discuss the mechanical characteristics of accessory control devices and the construction features of complete controllers.

REFERENCES

This article is the third in a series by J. Ronald Wickey on dc motor control. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. Motor Types and Characteristics ..... July 20, 1961
2. Circuit Functions of Control Devices ..... August 3, 1961



Prefinished ribbed stainless steel, used for door of slide projector, combines utility with visual appeal. Material is 0.008 in. thick, AISI Type 430, with a satin finish. (Photo, courtesy American Iron and Steel Institute.)

A design guide for specifying . . . mechanical

SURFACES of metal parts can be mechanically treated to remove scratches or pits, to produce a smooth, lustrous sheen, or to provide a base for subsequent plating or other finish coatings. Although the sequence of grinding, buffing, and polishing operations may vary for different types of parts and for different materials the mechanical operations are fairly standardized and may be discussed separately. Basically, each operation removes high spots from a rough surface, either by the cutting action of an abrasive or by the flowing of surface metal.

Mechanical surface treatments also include such operations as hammering, pattern rolling, and highlighting which produce a design or texture. Subsequently, surfaces may be lacquered, anodized, or either partly or entirely painted to obtain specific decorative effects.

• Types of Finishes

High-luster parts are bright and shiny when first put into service, but they can show fingermarks and can be scratched easily. A high-luster finish on a part requires that all surface defects be removed.

Articles with satin or dull finishes generally retain their appearance for a longer time and are not easily marred. A satin finish blends with die marks and surface scratches—an advantage that usually results in fewer finishing operations.

In general, consideration should be given to part design to eliminate all unnecessary projections, impressions, angles, and recesses. Simplifying the design minimizes finishing operations and eliminates the necessity of using narrow, small, or special types of wheels. Savings in polishing and buffing operations often offset the cost of additional machining

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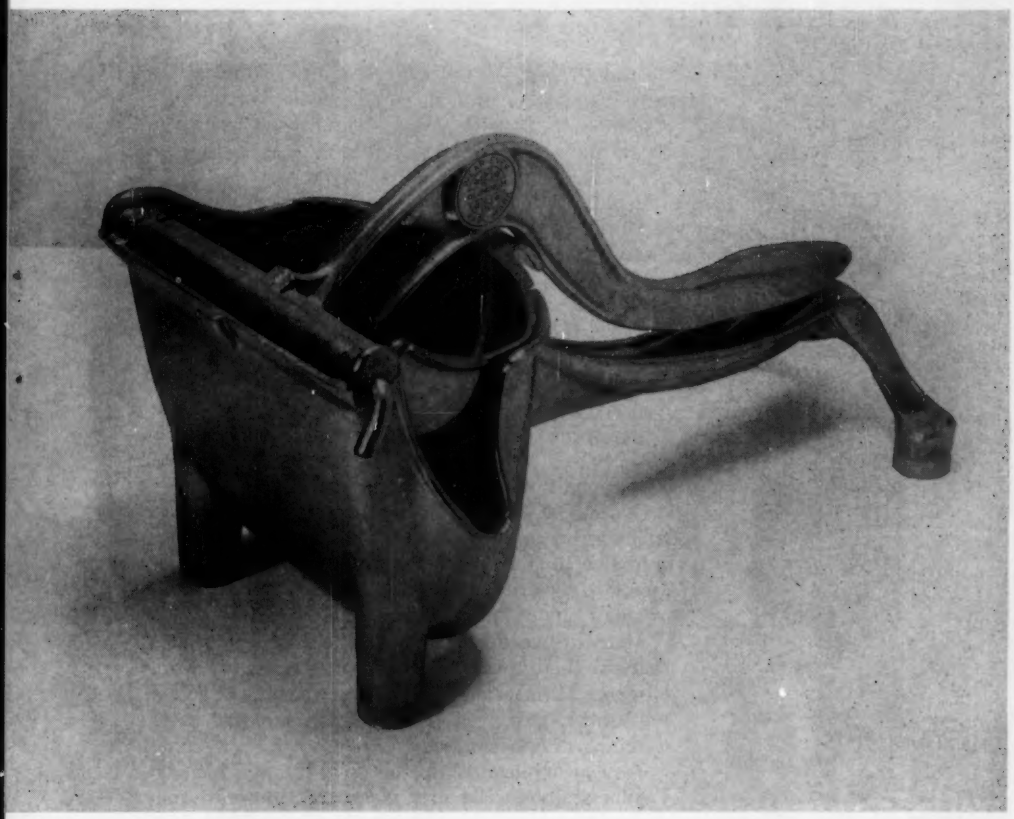


Barrel burnishing produces a smooth, economical finish on die-cast aluminum juicer. (Photo, courtesy Aluminum Co. of America.)

finishes for metal parts

LESTER F. SPENCER
Metallurgist
Cleveland, Ohio

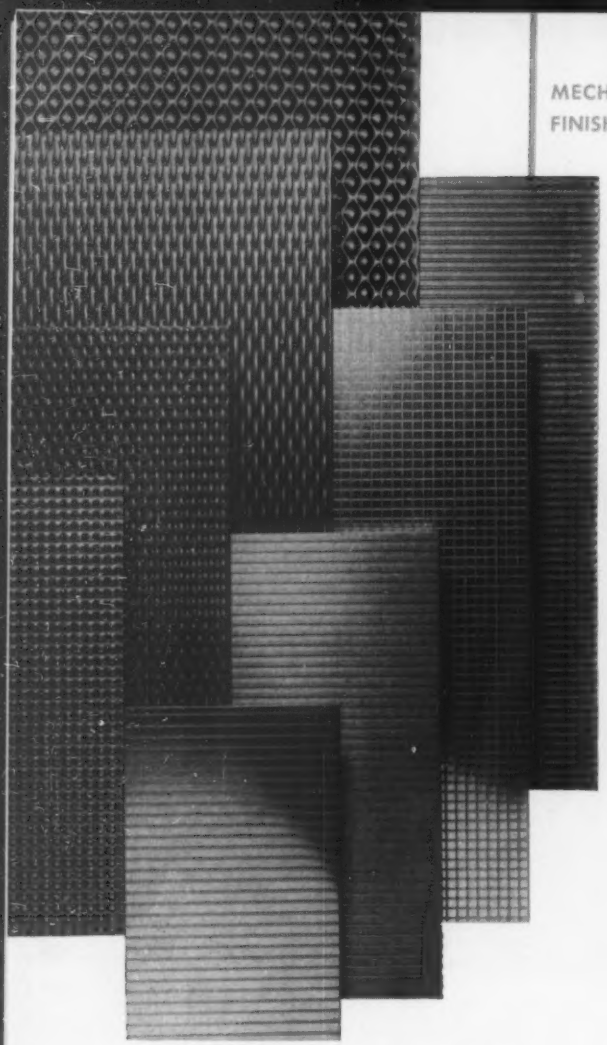
operations.

Some common finishes are:

- **Matte.** Produced by a sand-blast treatment or an acid dip. The surface is nonreflecting and completely free from parallel lines.
- **Scratch brush.** Consists of a combination of coarse and smooth textures with a slight, underlying luster. Degree of coarseness is determined by wire size of the rotating brush that produces the finish. Uniformity of results depends on the part material, and on the diameter, speed, and pressure of the brush. Another factor that affects surface quality is the ability of the equipment to remove from the work surface accumulated oxide, dirt, or metal particles that are produced by the operation.
- **Satin.** A modification of the scratch-brush finish, produced by scratching the surface with a fine abrasive or with a rotating wire brush. A soft, smooth sheen is obtained. The angle of brush contact may be changed to give various effects.
- **Luster.** A near-mirror finish obtained by a sequence of polishing and buffing operations. The resulting surface has no visible defects.
- **Butler.** Composed of fine, parallel lines, with a characteristic luster more definite than any other abraded or lined finish. This finish is used mainly in the silver industry and is classified as "dull butler," "butler," or "bright butler," according to the degree of brilliance achieved.
- **Colonial.** Achieved by soft-brushing the high areas of a rough, oxidized surface. Highlights are satin finished to create a contrast against the oxidized background. Parts with raised or embossed designs are often treated in this manner.

• Finishing Methods

Since a variety of procedures is used to fabricate metal parts, surfaces can vary from smooth, amorphous-type skins to those that are extremely rough.



Aluminum patterned surfaces hide scuff marks, provide increased rigidity, and offer an attractive appearance. (Photo, courtesy Aluminum Co. of America.)

Surface condition, material to be processed, and character of desired finish are the factors that influence specifying a finishing procedure.

For example, removal of a scale formation by a chemical treatment or by blast-cleaning may be an initial step. This might be followed by a grinding operation to take out surface defects. Polishing could be the next step—usually a multistage procedure which produces a smooth, uniform surface. As the polishing approaches the finer surfaces with higher lusters, the tendency to burnish the surface increases. The final finish, whether it be satin, brushed, butler, or high luster, is obtained by buffing.

Abrasive Blasting: In this process, an abrasive material—metal shot, sand, flint, silicon carbide, or aluminum oxide—is propelled against the surface to be cleaned. Dry blast-cleaning methods use air pressure for the propulsion means; wet methods use pumps, Table 1.

Compared to chemical-descaling methods, blast cleaning is a more economical process, both from the labor and equipment standpoints. In many operations, the abrasives are recoverable, although reclassification of grit by a screening process is usually necessary.

Effects of blast cleaning may be controlled by: 1. Hardness and type of abrasive grain. 2. Particle size of abrasive material. 3. Velocity of abrasive stream. 4. Method used to direct the abrasive stream. 5. Method used to direct the work flow.

Selection of particle size of the shot or grit is governed by thickness of the parts to be cleaned or treated. Thin-walled sections may be cold-worked too severely—or even damaged—if the particle size of the abrasive is too large. Particle size also affects surface condition—finer finishes are obtained, of course, with the smaller particles.

Control of particle size is important also because an excessive amount of fines increases the time required to produce a specific finish. Screening is required to remove both fines and foreign material such as small bits of scale and metal.

Abrasive blasting can be used to produce surfaces that are both chemically and mechanically clean. However, surfaces that have a heavy coating of grease must have the gross contamination removed prior to the blasting operation.

Typical applications for abrasive blasting include: 1. Increase of surface area of a part to improve mechanical bonding of an organic or electroplated coating. 2. Removal of lines, feather edges, and metal fuzz produced by grinding and polishing operations. 3. Removal of burrs from machining operations. 4. Improvement of a finish.

Various decorative textures can be produced by abrasive blasting—such as those used in architectural trim and paneling components. For a highlighting effect, the raised portions are masked while the recessed areas are sand-blasted. The maskant is then removed and the raised areas are buffed to a luster.

Abrasive blasting will not improve a surface that is uneven or pitted. Nor will it be as effective on a rough-ground or machined surface as on a part that has a fine-ground surface. Particularly with the finer grits, success in obtaining a desired surface finish depends upon its prior condition. Abrasive blasting cannot be expected to produce a finished dimension, but by a proper selection of abrasive type and size, application, pressure, and angle of impact, abrasive blasting can be used to maintain a dimensional tolerance.

Grinding: Deeply scratched or uneven surfaces, such as on rough sand castings and forgings, usually require a grinding operation, since significant amounts of metal must be removed. Equipment usually consists of a rotary grinder arrangement using a bonded abrasive cup wheel or a canvas wheel faced with an abrasive such as silicon carbide, aluminum oxide, or emery. Abrasive size may vary from 25 to 50 grit. Wheel speed is usually low to avoid overheating

Brass drinking-fountain head, formerly a sand casting, is now made as a forging to reduce finishing operations. Part is shown, left, as forged; center, machined; right, polished, buffed, and plated. (Photo, courtesy Copper and Brass Research Association.)

Table 1—Abrasive Blast-Cleaning Methods

Method	Uses	Advantages and Disadvantages
Direct Pressure: A dry method. Compressed air at 80 to 90 psi is maintained from the point of introduction of abrasive in the line to the tip of the nozzle. Abrasive flows into the line by gravity.	Removal of scale from heavy-section castings and forgings.	Provides maximum energy of abrasive impact. Equipment and maintenance costs are high. Metal erosion in gun is high.
Induction Gravity: A dry method. Abrasive flows into line by gravity. This method differs from direct pressure system in that abrasive is sucked into the gun by a partial vacuum.	Removal of scale and other solid contaminants from castings and forgings with moderate to heavy section thicknesses.	Less efficient than direct-pressure type. Lower initial and maintenance costs than direct-pressure method. Metal erosion in gun is high.
Induction Suction: A dry method. Similar to induction gravity type in that abrasive is brought into the gun by a partial vacuum. But abrasive is lifted into position rather than being under gravity flow.	Blasting of surfaces that are easily cleaned. Scale removal from delicate electronic parts. Burr removal from machined parts.	Least effective of the dry methods. Lowest initial and maintenance costs. Greater variety of abrasives may be employed. Metal erosion in equipment is high.
Liquid Impact: A wet method. Abrasive is suspended in a liquid and delivered to the nozzle by circulating pump. Suction-feed method is used to bring abrasive into blast gun at low pressures.	Deburring of finished materials such as precision-machined parts. Also used for liquid-honing prior to hard-chromium plating, for decorative finishing, and for polishing of small-cavity dies.	Highly flexible method. Abrasive particle size may vary from 60 to 5000 mesh. Erosion of equipment is low. Initial equipment is relatively expensive; maintenance, moderately expensive.

Prefinished stainless-steel sheets provide attractive, easily cleaned surfaces on hospital oven and refrigerator. Material is AISI Type 302, with a No. 4 finish. (Photo, courtesy American Iron and Steel Institute.)

Finish on aluminum mail-chute casting consists of sand-blasted background, belt-polished highlights. (Photo, courtesy Aluminum Co. of America.)

and dragging of the surface.

Progressive grinding refers to a succession of operations in which wheels of decreasing grit size are used. Direction of wheel traverse across the work is changed by 90 deg with each operation to remove the grinding lines made by the previous grit. Work surfaces must be cleaned thoroughly between operations so that any abrasive particles or metal cuttings do not interfere with the performance of the finer grits. Dry grinding is usually preferred to wet.

Polishing: This operation is an abrading process that usually follows grinding in sequence. Polishing also removes metal in preparing the surface for final finishing. However, due to the finer grits that are used, polishing differs from grinding in the degree of metal removal.

Conventional polishing wheels—those coated with hot glue or cold cement, then rolled in abrasive grain—are used particularly for the coarser operations. Dry, abrasive-coated, flexible wheels are used for finer finishes. Cutting faces of these wheels are formed and maintained by periodic frictional transfer of an abrasive-containing compound.

Commonly used polishing wheels are constructed of muslin, felt, canvas, or leather which offer varying flexibility to suit the work part and its surface condition. The hardest wheels are made of individual discs of canvas cemented together; the softest are composed of discs of muslin sewn together. Pressed felt wheels are easily contoured to fit irregularly shaped articles. However, their higher initial cost limits their use to the finer abrasive grit sizes. Solid leather wheels are tough and resilient and are used for fine polishing. Wooden wheels covered with leather are often used for flat surfaces, where flexibility is not required.

Generally, the more rigid wheels are used for rapid metal removal from flat surfaces. The softer, flexible polishing wheels are used on irregular surfaces and where fast removal of metal is not the prime requisite.

The most widely used abrasive is aluminum oxide. The grains are sharp, hard, fast cutting, and long wearing. Silicon carbide, which fractures when dull, thus providing new, sharp, cutting edges, is used where cutting properties are desired. However, since it does not bond well to conventional wheels, it is used to a limited extent.

Polishing-wheel faces are often lubricated with water to prevent gouging of surfaces and to minimize frictional heat when the softer metals—particularly aluminum—are polished. As in grinding, progressive polishing operations are normally used to obtain a base for final finishing operations.

Buffing: The function of a buffing operation is to produce a smooth, uniform surface with a high luster. Abrading action is at a minimum. A fine abrasive is blended with a lubricant which causes a flowing action of the surface rather than one that gouges or scratches. Buffing is normally a two-step process: 1. A "cut-down" buff which changes a relatively rough, polished surface into a smoother one. 2. A "coloring" buff which produces the high finish or luster. Subsequent operations which produce

Table 2—Surface-Finishing Characteristics of Metals

Aluminum and Aluminum Alloys

These soft metals have a high coefficient of friction and a tendency to tear if overheated during an abrading action. This characteristic limits the choice of finishing procedures to those where a liberal application of lubricant can be used and where a minimum amount of pressure can be applied. Recommended procedure is to use the least number of operations permitted by both the hardness and the original surface condition to obtain the desired finish. In many instances, an additional protective coat is not required because of the natural formation of a transparent, inert, oxide film on the surface. For applications where this oxide film may be destroyed by a corrosive environment or where a decorative coating is desired, a supplementary protective electroplate, anodize, or organic finish is used.

Magnesium and Magnesium Alloys

Finishing procedures for these materials closely parallel those used for the aluminum-base alloys with the exception that certain magnesium alloys (because they are harder) do not drag or tear. This characteristic reduces the need for a lubricant during finishing. Although these materials show good resistance to corrosion in most atmospheres, the protective surface film that is formed does not remain metallic in appearance but changes gradually to a dark gray. For this reason, protective coatings are usually used on these materials.

Zinc Alloys

Zinc buffs easily. Die castings are often plated. Since plated coatings cannot cover defects, the work performed prior to plating governs the final appearance of the plated surface.

Copper and Copper Alloys

Special methods and abrasives must be used for surface finishing of these soft metals. Because copper flows readily during polishing and buffing operations, copper electroplate is used extensively as an undercoat for nickel electroplate.

Nickel and Nickel Alloys

Nickel and high-nickel alloys respond well to most finishing operations. For indoor service, these metals remain reasonably bright and free from tarnish. However, some dulling may be anticipated upon outdoor exposure. Nickel is one of the more important metals that is applied as an electro-deposit. Because of the high copper content of most nickel-base alloys and the tendency toward tarnishing, subsequent electrodeposited finishes are usually used.

Silver

Silver is seldom used in the pure state, but mainly as an alloy, with copper as the alloying element to increase hardness and wear resistance. Due to the relatively high cost of these alloys, great care is justified in specifying procedures that will minimize metal losses during finishing.

Steel and Stainless Steel

The same general finish procedures apply to both classes of material. Because stainless steels are usually harder than carbon steels, more time is required to produce a specific finish. Greater care must be used to avoid overheating the austenitic stainless steels so that warping and buckling of thin sections does not occur. Some of these steels work-harden and transform at a relatively low temperature which complicates the polishing and buffing operations. Carbon steel is frequently used as a base for electroplating. Because of the natural attractiveness and corrosion resistance of stainless steels, additional protective coatings normally are not required.

satin, brushed, or butler finishes may be used.

Buffing compounds include extremely fine abrasive powders such as unfused aluminum oxide, chrome rouge, Tripoli, and lime silica. The choice is sometimes influenced by the protective coating that follows. For example, with aluminum that is to be anodized, it is important to avoid abrasives that may contain iron oxide, such as Tripoli. Even a trace may cause a cloudy coating.

Buffs are flexible wheels of cloth, paper, or sheepskin discs. Those made of high-count cotton cloth are generally used for cut-down operations; flannel or wool cloth buffs are used for coloring. Muslin buffs, bleached and unbleached, with counts up to 86 by 93, are used for heavy service on brass, copper, nickel-silver, or nickel surfaces. Softer, lower-count muslin buffs are used for high coloring of the noble metals.

Barrel Finishing: This process is used to deburr and brighten small parts in large quantities and to produce a bright finish on parts that would be difficult to buff and polish by other methods. Barrel finishing (tumbling) is used for eyelets, screw machine parts, small stampings, and other parts that are not adversely affected by the tumbling action.

Two types of barrel finishing methods are used:
1. Deburring—a cut-down or honing operation.
2. Ball burnishing.

Granite chips, aluminum oxide, carborundum, or sharp silica sand are some of the abrasives employed in deburring. Cutting action varies with the volume of water included in the charge. Less water speeds grinding; more water produces a better finish but lengthens the cycle.

Ball burnishing is often used to bright-finish parts without removing metal. A high surface luster is developed by the action of steel balls, cones, discs, and pins either singly or in various combinations. These burnishing pieces should have smaller radii than the work if all areas of the work are to be polished.

Abrasive Belts: Finishing operations using coated abrasive belts (instead of wheels) cover several phases of surface preparation including grinding, polishing, and buffing. The finish obtained depends, of course, on abrasive type, grit size, and hardness and configuration of the contact wheel.

Finish procedure on extruded bronze window section consists of a hand-rubbed pumice operation followed by an oxide coating and a final wheel-polishing operation. (Photo, courtesy Copper and Brass Research Association.)

Dry-belt grinding is primarily used on nonmetallic materials such as wood, cork, rubber, and thermosetting plastics. However, it is used also to a limited extent for light surface grinding of both ferrous and nonferrous materials. Limiting factors are heat, dust, and degree of belt loading.

Wet-belt grinding is particularly effective for parallel surfacing of metals, especially for work that requires extreme flatness or close dimensional accuracy.

Contact wheels for abrasive belts are made from rubber, metal, or cloth. Commercially available wheels include:

- **Plain-faced rubber wheel.** Hardness varies from a Shore durometer value of 20 to 90. As hardness of the wheel increases, the surface finish it produces becomes rougher. This wheel type is used for intermediate and final finishing, for finishes ranging from 100 to 10 rms. Wheels may be contoured to permit grinding or polishing of curved parts.
- **Serrated rubber wheel.** Lands and grooves are cut into the wheel face. Promotes fast cutting as required in rough grinding and intermediate polishing. Part finish ranges from 150 to 20 rms.
- **Cog-tooth rubber wheel.** Face configuration is much like that of a milling cutter. Lands are thinner than on a serrated wheel, permitting the application of higher pressures. Part finish ranges from about 200 to 25 rms.
- **Flat-faced steel wheel** (with knurled or coarse-thread face). Knurling permits the escape of lubricant used in this operation. Abrasive grain is progressively broken which provides new cutting edges. Part finish varies from 200 to 35 rms.
- **Compressed-canvas wheel.** Used for all types of finishing. Wheel may be contoured so that the face fits a part configuration. Part finish ranges from 100 to 10 rms.
- **Bias-cut folded cloth wheels.** Used to impart a high finish. Wheels are self conforming to a limited extent. Part finish ranges from 70 to 3 rms.

As in wheel-polishing operations, the two most widely used abrasives for belts are silicon carbide and aluminum oxide. Grit size for roughing operations should include a grain size up to about 60; for polishing, 80 to 180; for finishing, up to 500.

Belts provide a large work area as compared to wheels. However, due to the flexibility required for belt travel, the coated area is only one layer thick. With polishing wheels, the abrasive area is much smaller, but a thicker abrasive head can be used.

• Specifying Finishes

Important factors that influence a finish include the type, size, and speed of polishing and buffing wheels. By varying these factors only (and using one grade of compound), as many as fourteen different finishes can be obtained, ranging from striking highlights to dull satins.

Wheel pressure is also an important variable that should be determined by test for each class of work.

Part Material: A hard material such as stainless steel, will take a higher luster than a softer metal such as aluminum. Additionally, since surface hardness is influenced by cold working and heat treatment, the fabrication history of a part must be considered when a procedure for surface finishing is specified. Basic characteristics of several classes of metals with respect to finishes are given in Tables 2 and 3.

Because of the cost of obtaining a high-luster finish, particularly on a fabricated part, it is common practice to specify as high a finish on flat sheet stock as is compatible with the type of fabrication contemplated. Austenitic stainless steels, for example, can be specified with a dull, pickled surface, or a high-luster finish. The reason is purely economic. It is less expensive to obtain a high finish on a flat product because automatic equipment can be used.

For deep-drawn parts, a dull finish is invariably used. For moderately formed shapes made from stainless steel, a fairly bright surface finish is used. In many instances, the surface is protected during press fabrication. Parts can then be buffed after forming to remove any marks from the fabrication operation.

As fabrication becomes less severe, the advantages of specifying a higher-luster sheet increase. For some parts it may be necessary to start with a highly finished sheet since the fabricated item may be too complex to polish and buff to a satisfactory finish.

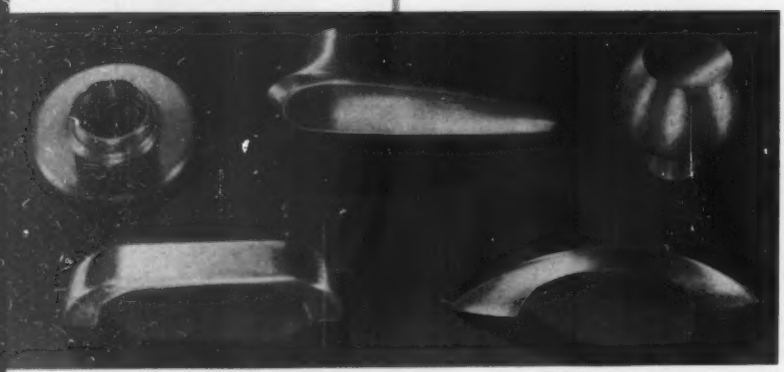
Welded Parts: Welded stainless-steel parts such as sinks, washing-machine tubs, and sanitary equipment require a programmed procedure for finishing to color-match the welds with the base metal. First, a grinding operation removes excess weld metal. Grinding is terminated sufficiently above the level of the base metal so that subsequent polishing and buffing operations will not produce a groove. Polishing operations with progressively decreasing abrasive grit sizes follow, and the final color match is obtained by buffing operations. To obtain a scratch-free, mirror surface and a perfect color match between

Table 3—Mechanical Finishes for Stainless Steel, Copper, and Aluminum Parts

Finish	Appearance	Procedure	Uses
Smooth, lustrous, (as buffed)	High-luster, smooth surface. Reflectivity can be increased by operations such as electropolishing of stainless steel and chemical brightening of aluminum. Copper-base alloys are frequently electroplated or clear lacquered. Used on aluminum prior to anodizing.	Polished surface is buffed, using progressively softer buffs and/or finer abrasives. Surface cleanliness between operations is of utmost importance.	Household appliances, trim, reflectors, sanitary equipment, and jewelry.
Smooth, lustrous, (burnished)	Not as bright as a buffed surface. Brightness depends upon base-metal finish, treatment time, and relative movement and pressure of burnishing wheel.	Small, nonfragile parts are tumbled in a barrel containing a neutral soap solution and small stainless steel balls. Burnishing time increases with metal hardness. Uniform finish difficult to obtain on complex designs.	For similar applications as buffed parts but particularly for parts that are difficult to polish and buff. Typical parts include pen points, eyelets, grommets, fasteners, and screw-machine parts.
Satin, (wheel or belt polished)	A smooth, satin-finish sheen. Tampico-brush wheels produce slightly duller surfaces than abrasive wheels.	Standard polishing and buffing operations using progressively finer grits are used to produce this finish.	Used where low reflectivity is desired such as in cafeteria equipment, utensils, knobs, dairy equipment, and handles.
Satin, (wire brushed)	Usually brighter than a polished satin finish. Sheen depends on wire size. The thinnest wires (about 0.002 in.) produce the finest finish. Angle of contact of the brush may be changed to give various effects.	Fine parallel lines are produced on the surface by scratching it with a rotating wire brush.	For similar applications as wheel-polished satin finish. Used mainly on the softer alloys.
Matte, (sandblasted)	Textured surface. Texture depends upon abrasive material, air pressure, and distance and angle of blast nozzle from the work. Special decorative effects can be obtained. Surfaces are usually protected with lacquer.	The surface is sprayed with an abrasive such as silica, alundum, emery, corncobs, rice hulls, or steel particles.	For contrasting effects in softer metals. Also used, however, on stainless steel and copper-base alloys.
Textured, (semibright)	Similar to wrought silver. Minor surface flaws are hidden by pattern.	Irregular depressed pattern is produced with ball-peen hammer or similar tool.	Used on copper and aluminum jewelry and decorative items.
Textured, (embossed or engraved)	A patterned finish. Numerous effects such as diamond, stucco, ribbed, and herringbone patterns can be produced.	Sheet is passed through embossing rolls or is pantograph-engraved.	A reinforcing effect is obtained which sometimes permits reducing metal gage. Used for panels, nonskid surfaces, nameplates, and automotive trim.

base metal and weld, as many as fourteen operations may be necessary. Finishing costs can be reduced, of course, if a scratch-brush or a satin finish will suffice.

Plated Surfaces: When the base metal of a part is covered with a second metal—an electrodeposited surface—finishing of both surfaces is usually required. However, if the plate is relatively thin, the finishing of the base metal is of greater importance since a thin electroplate has little hiding power. Conversely, if a relatively heavy deposit of



Satin finish on aluminum hardware items can be achieved by fine wire brushing, or buffing with an abrasive compound on a conventional buffing head, tampico-brush wheel, or brush-backed sander head. (Photo, courtesy Aluminum Co. of America.)

metal is placed on a base material, the finishing of the electrodeposit is of prime importance. In all cases, gross imperfections of the base metal surface should be removed.

Copper is frequently deposited as a heavy film—about 0.001 in.—for the protection of steel parts and zinc-base die castings against corrosive environments. In such applications, the finish of the base metal is secondary.

Generally, copper is used as an intermediate deposit, followed by nickel and chromium. If the final finish is to have a high luster ("high-color"), the cut-down and color-buffing operations are performed on the copper deposit before the final plating is done. No further buffing other than touch-up is required. However, if the plating sequence includes deposition of a soft nickel electroplate, as is obtained from a Watts bath (which produces a dull-appearing plate), it is only necessary to cut-down buff the copper deposit, color-buff the nickel deposit, and then follow with bright chromium.

In such composite coatings, a satin finish is frequently produced on the initial copper deposit. The subsequent nickel plate is then satin-finished with a fine abrasive prior to the final bright-chromium plate. When the nickel is deposited directly on the base metal, it is buffed and satin-finished in the same manner.

In cases where bright nickel plate is deposited on a well "cut-down" base metal, additional buffing is not required to obtain a high-color finish. If a satin finish is required on a nickel surface, this effect should be produced on the base metal. Then, if necessary, a light satin finish may be produced on the bright-nickel plate. Finishing lines on both operations should be in the same direction.

Decorative chromium plate—usually on the order of 0.00002 in. thick—shows any imperfections of an underlying surface. For this reason, the base-metal surface prior to plating should meet the requirements of the specified finish. When a relatively heavy deposit of chromium is placed on a part to serve as a hard, wear and corrosion-resistant surface, or as an antigalling coating, the deposit should be treated as if it were the base metal with regard to polishing and buffing operations.

Tips and Techniques

Approximating e^x and ln x

The following equation gives an accurate approximation of e^x for the range between $x = 0$ and $x = 1$:

$$e^x \cong \frac{2x + \sqrt{3x^2 + 9}}{3 - x}$$

Between $x = 0$ and $x = 0.4$, the approximation is accurate to four places; between $x = 0.4$ and $x = 1$, maximum error is 0.5 per cent. For even greater accuracy, when x is greater than 0.5, but less than 1, use $e^x = e/e^{1-x}$.

To calculate e^x for $x > 1$, let $x = y + a$, where y is an integer and $0 \leqq a < 1$. Then, $e^x = e^y + e^a$.

A simpler but somewhat less accurate approximation of the function e^x for x values between 0 and 1 can be found from

$$e^x \cong \frac{x^2 + 4x + 6}{2(3 - x)}$$

This method yields results with a maximum error of less than 1.2 per cent.

The value of ln x can be approximated from

$$\ln x \cong \sqrt{x^2 + 10x - 2} - (x - 2)$$

where the result has a maximum error of slightly over 1 per cent.—Sidney Kravitz, *Dover, N. J.*

Nomograms for determining

Radii of Gyration

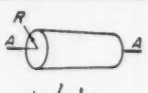
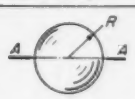
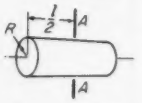
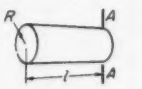
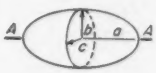
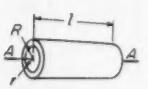
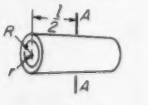
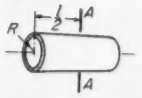
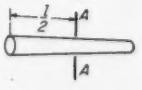
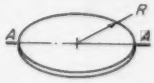
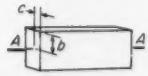
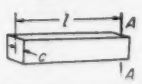
HANS W. SMITH
Research Engineer
Boeing Airplane Co.
Seattle, Wash.

BODY radii of gyration, which depend on geometry alone if body masses are homogeneous, are especially convenient in calculations of rotary motions, such as accelerations in starting and stopping turbine rotors, gears, flywheels, pendulums, and so on.

Normally, radii of gyration squared, i.e., k^2, are used in calculations. Here, values of k^2 are expressed as functions of the defining geometry of common body shapes. Nomograms enable values of k^2 to be found quickly when multiple dimensions occur.

Mass moment of inertia of a body I is found immediately by $I = Mk^2$, where M is body mass. To get an unknown k_u^2 from a known k^2 about a geometrical axis, the parallel-axis theorem is used; namely, $k_u^2 = k^2 + d^2$ where d is the distance between parallel axes. Any consistent set of dimensions can be used.

Equations and Nomogram Index

Description	Geometry	Fig.	Value of k^2	Description	Geometry	Fig.	Value of k^2
Circular cylinder or disc Geometrical axis			$\frac{R^2}{2}$	**Solid sphere** Axis at center			$\frac{2R^2}{5}$
Circular cylinder Axis at midlength		1	$\frac{l^2 + 3R^2}{12}$	**Spherical shell** Axis at center			$\frac{2R^2}{3}$
Circular cylinder Axis at end		3	$\frac{4l^2 + 3R^2}{12}$	**Solid ellipsoid** Longest axis		7	$\frac{b^2 + c^2}{5}$
Hollow cylinder Geometrical axis		6	$\frac{R^2 + r^2}{2}$	**Thin flat ring** A diameter		6	$\frac{R^2 + r^2}{4}$
Hollow cylinder Axis at midlength		5	$\frac{l^2}{12} + \frac{R^2 + r^2}{4}$	**Wheel rim or ring** Geometrical axis			R^2
Thin wall cylinder Axis at midlength		2	$\frac{l^2 + 6R^2}{12}$	**Wheel rim or ring** A diameter			$\frac{R^2}{2}$
Rod or tube of small diameter Axis at midlength			$\frac{l^2}{12}$	**Thin disc** A diameter			$\frac{R^2}{4}$
Parallelepiped Geometrical axis		7	$\frac{b^2 + c^2}{3}$	**Thin plate** Centroidal axis			$\frac{t^2}{12}$
Parallelepiped Axis at end		4	$\frac{l^2 + c^2}{3}$	**Thin plate** Axis in surface at median width			$\frac{t^2}{3}$

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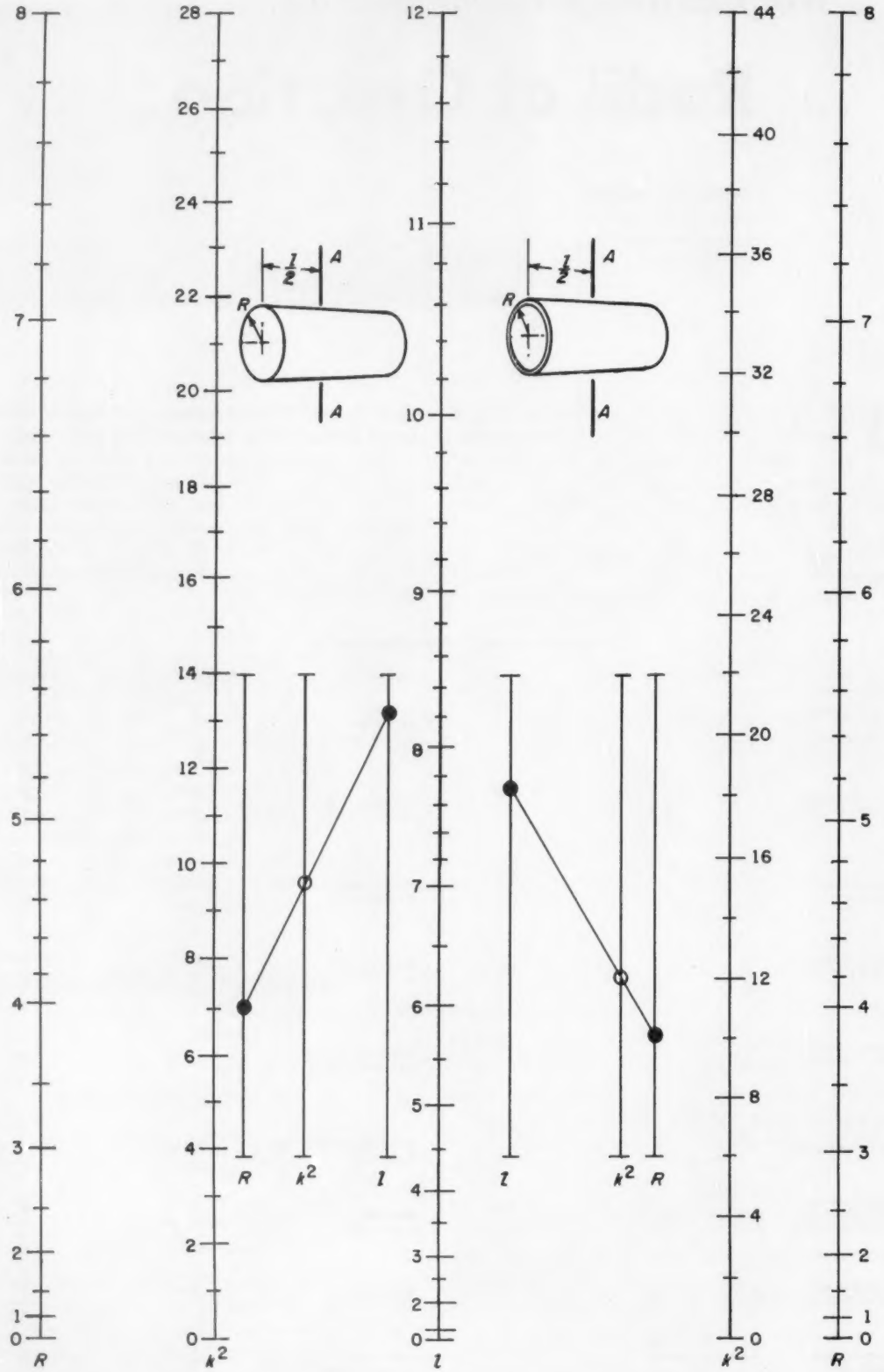

Fig. 1—Right circular cylinder about axis at midlength.

Fig. 2—Thin wall cylinder about axis at midlength.

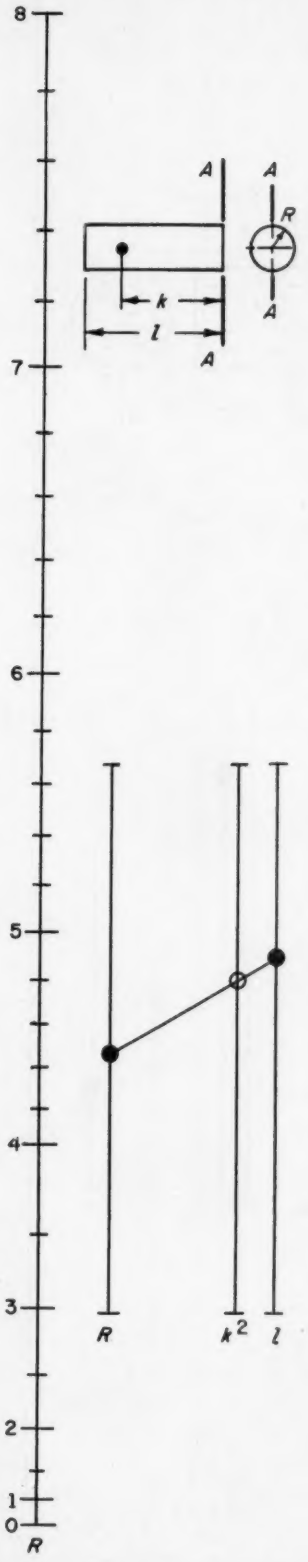

Fig. 3—Right circular cylinder about axis at an end.

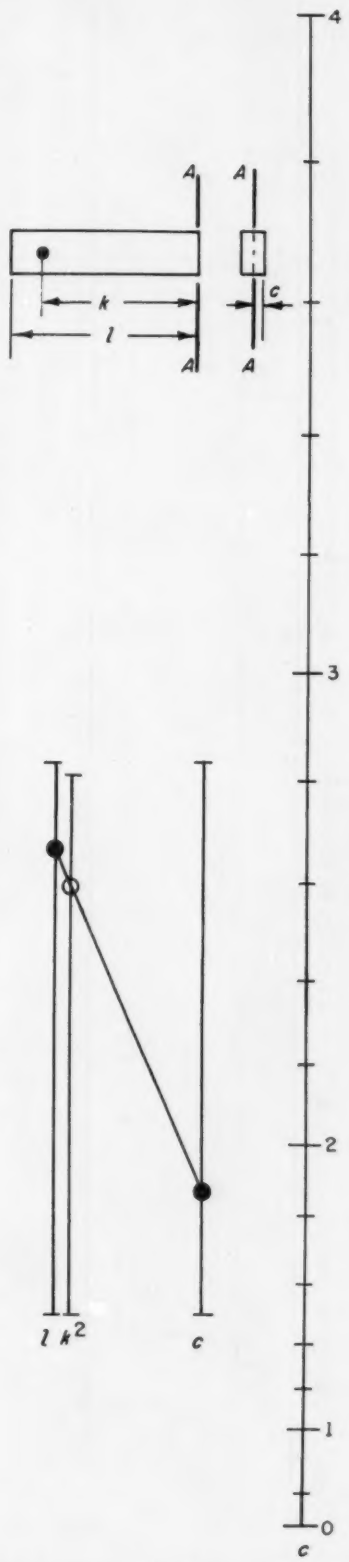

Fig. 4—Parallelepiped about median axis at an end.

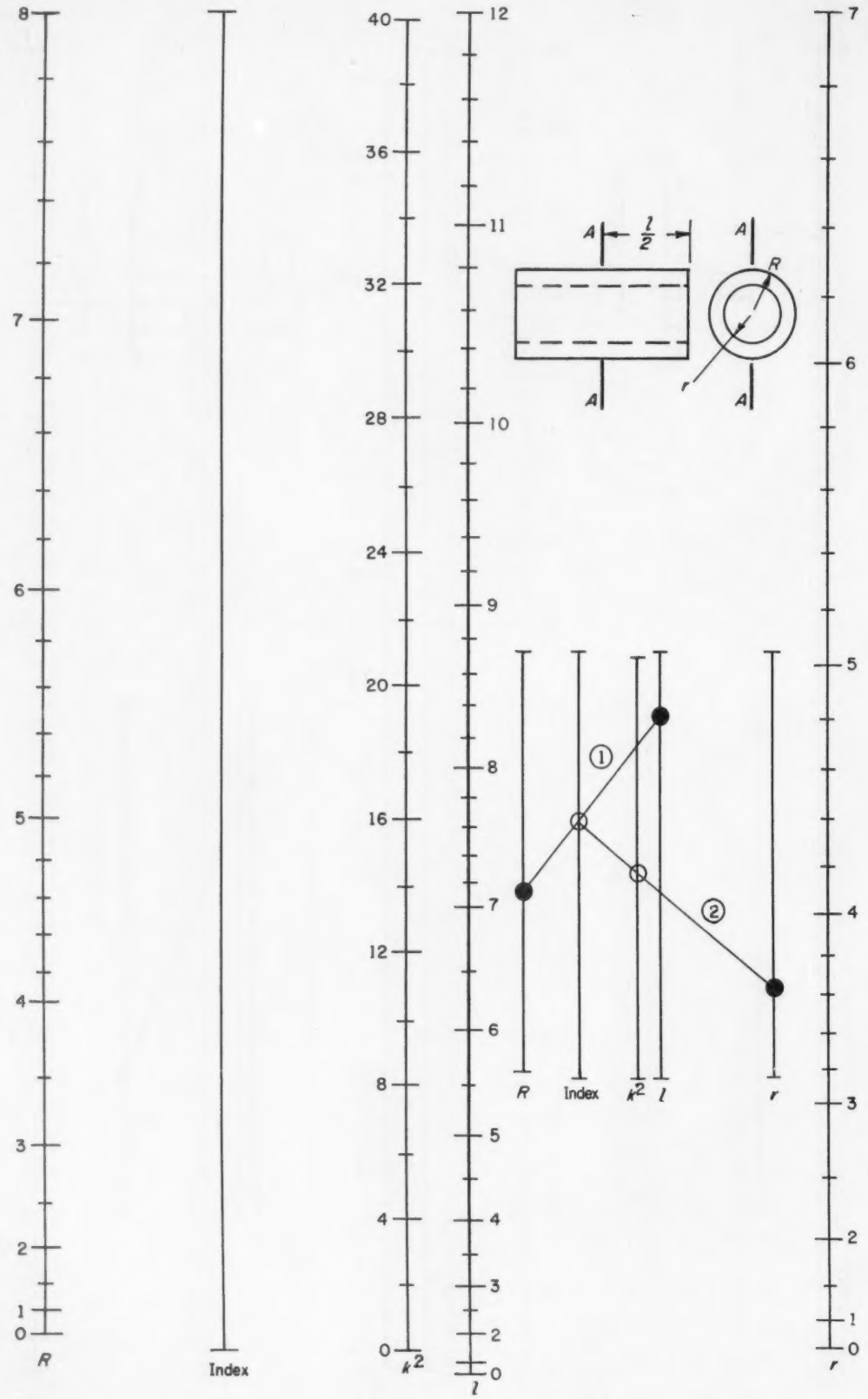

Fig. 5—Hollow cylinder about axis at midlength.

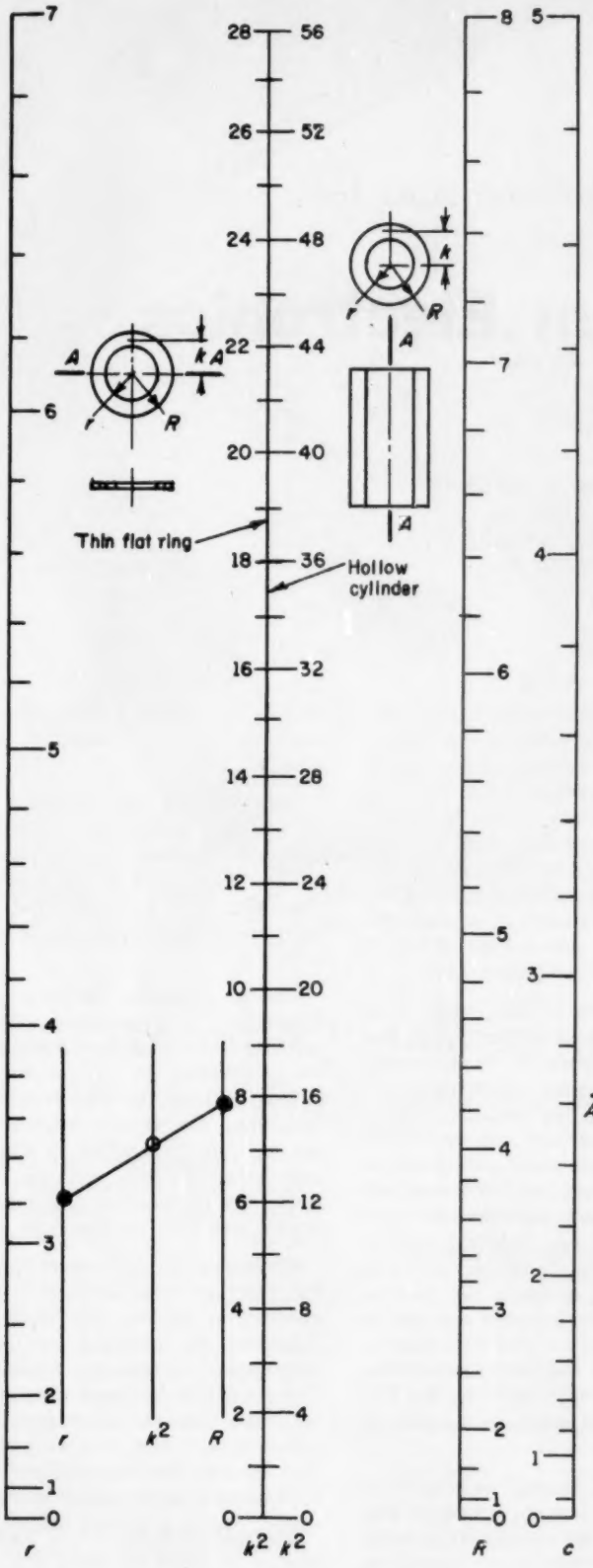

Fig. 6—Hollow cylinder about geometrical axis; thin flat ring about a diameter.

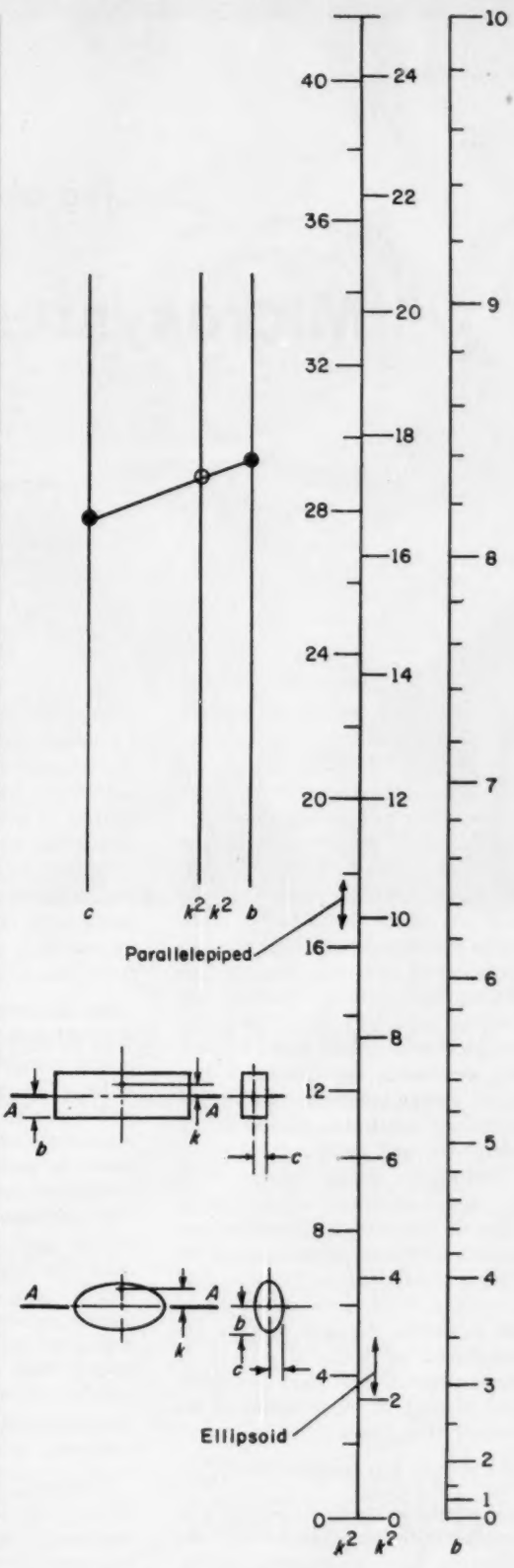

Fig. 7—Parallelepiped about longitudinal axis; an ellipsoid about longest principal axis.

Catalog of techniques for

Microsystem Electronics

PETER B. MYERS
Motorola Inc.
Semiconductor Products Div.
Phoenix, Ariz.

DOMINANT trends in modern electronic circuitry include improvement in reliability, decrease in size and weight, decrease in power consumption, and reduction of cost. Most problems associated with these trends occur in three areas: Fabrication, interconnections, and accessibility. As an aid for solution of fabrication problems, this article presents a catalog of electronic microsystem techniques. Catalog contents are classified according to ten basic circuit parameters: Insulation, conduction, resistance, capacitance, inductance, special networks, active elements and substrates, encapsulation, mechanics, and design.

Techniques which develop these parameters sometimes use bulk properties of the body of the substrate, sometimes operate at or close to the surface by alloying or diffusion, and sometimes build elements on top of the substrate. Building can be accomplished by epitaxial growth of semiconductor materials, evaporation, plating, or other means of depositing thin films.

Insulation

Extrinsic techniques of insulation include operations external to the substrate. Extrinsic electrical insulation methods include: Anodization, vapor-phase deposition of dielectrics by pyrolysis, evaporation, and plasma deposition techniques as well as conventional mechanical coating.

Intrinsic insulation includes any method of isolating fields or current flow within a semiconductor or other substrate. Among these are: Thermal oxidation, fabrication of an isolating layer of intrinsic semiconductor material, and creation of one or more back-biased junctions.

Anodization is the formation of an insulating oxide over certain elements, usually metals, by electrolytic action. The most commonly anodized materials are tantalum, aluminum, titanium, and niobium. Anodization is particularly useful where protection of a conductor is required. The base metal can form the conductor and the anodized surface layer can form the insulator. Anodized films of tantalum can be controlled to a high degree and possess a dielectric constant of approximately 25. High dielectric constant becomes a disadvantage as the frequency of the energy to be insulated increases.

Pyrolysis is thermal decomposition of a volatile chemical compound into nonvolatile and volatile byproducts. It is generally carried out in an inert carrier gas, and this fact distinguishes it from vapor plating. Silica, silica-based glasses, and silicone polymers have been deposited successfully.

Evaporation is the deposition in high vacuum of insulation which is thermally liberated from a parent source. Silica films of low optical absorption have been produced by electron bombardment of the parent oxide.

Plasma deposition involves the spraying of highly excited atomic particles of the insulator. Heat, commonly obtained by electric arc or hydrogen flame, is the source of excitation. Almost any elementary material can be applied to almost any surface by this method. Disadvantages are grossness of the spray process and high temperatures.

Mechanical coating covers spraying, painting, or other physical application of organic and inorganic insulators. By means of extrinsic techniques, broad-area dielectric-film insulation has been developed with field strength in excess of 10^6 volts per cm. These insulating films can be reproducibly obtained to thicknesses in excess of 10 microns.

Thermal oxidation is the formation of a self-oxide upon the exposed surfaces of a semiconductor. The intrinsic insulation of silicon

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has been developed to a high degree by this method. Oxidation of parent material can be used to insulate broad areas.

Intrinsic layering refers to the method of separating two regions of conductive semiconductor by a region of near-intrinsic semiconductor material. This material differs enough in resistivity from the adjacent regions to serve as an insulator.

Back-biased junctions may be formed within semiconductor substrates to provide a type of insulation. With reasonable values of reverse bias, the capacitance across a graded junction can be reduced to the point of insignificance for low-frequency applications. The division of semiconducting substrates into two or more regions, isolated by reverse-biased junctions, opens the way to an eventual increase in the number or complexity of the functions that might be built into a single substrate. A disadvantage of the technique is the collection of any minority carriers in the area.

Conduction

The term conduction indicates electron current on or in substantially ohmic material of negligible resistance. One objective is to achieve integration of circuit functions on and within substrates so that ohmic connections from one location on the substrate to another are drastically reduced or eliminated. In cases where this is impossible or impractical, extrinsic conducting paths are formed by evaporation of metals, by painting or plating of conducting stripes, by sputtering, by pyrolysis, or by mechanical coating.

Intrinsic conduction can be accomplished by development of degenerate regions within the semiconducting or substitute substrate. This can be done by creating alloyed, epitaxial, or melt-grown regions during or following crystal growth.

Evaporation of conductors covers the vaporization of metals at high temperatures in vacuums of 10^{-4} mm Hg or better. The metallic vapor moves in substantially straight lines onto a substrate which may be mechanically masked to limit the deposition to desired regions. The substrate must be very clean and must generally be raised to an elevated temperature to assure intimate contact of the particles with the substrate.

Alternative means of producing conductive patterns involve coating an entire surface and subsequently removing unwanted conductive material. Evaporation may be of a single metal or an alloy. In the latter case, the deposition may be made simultaneously from a common source or sequentially from separate sources.

In the study of conductors by deposited techniques, resistivities less than one order of magnitude higher than metal conduction have been achieved. Where mechanical or thermal considerations make adhesion more important than achieving the lowest ohmic resistance, the introduction of a chrome-gold alloy has been useful.

Sputtering differs from evaporation in the conditions under which the conductive material reaches the substrate. Sputtering is the result of a glow discharge between an inert anode and a bombarded cathode of the desired conducting material. Because the presence of gas at 10^{-2} to 10^{-4} mm Hg is necessary for the generation of the ionized bombarding molecules, sputtering is inherently harder to keep clean. Even so, sputtering has advantages over vacuum evaporation in the relatively lower temperatures needed.

Pyrolysis is used for deposition of conducting films. It has the advantage of flexibility of materials and conditions of deposition. Disadvantage is that deposited material cannot be masked by mechanical shields as satisfactorily as the vacuum evaporated materials. Pyrolysis finds application where an entire surface can be coated as for electrostatic or magnetic shielding, or where unwanted material can be removed selectively after deposition.

Plating of conductors includes electroplating, chemical or electroless plating, and vapor plating. Electroless plating tends to cover everything, as does vapor plating. Selective removal of unwanted material can be combined with electroplating to build up conducting paths. Both electroplating and electroless plating are subject to contamination from the wet chemistry involved.

Mechanical coating includes conductive glass pastes which can be painted onto gross terminal pads to bridge irregularities that vapor deposition cannot manage. It also includes various solders for temporary use in making conductive paths to external terminals. Conductive glasses bond well to many substrate materials and are reasonably matched in thermal expansion coefficient.

Degenerate regions are regions within a semiconductor substrate in which the conductivity is very large and in which carrier transport is essentially ohmic. These regions are generally produced by alloying near saturation concentrations of a doping impurity into a specific pattern. Because of this method of formation, the paths are generally at the surface of the substrate. By control of intrinsic techniques, resistivities of 10^{-3} to 10^{-4} ohm-cm can be obtained.

Resistance

Resistance may be provided in at least four ways. Three intrinsic ways are by bulk resistivity, by transverse conduction in thin diffused back-biased regions within a semiconductor substrate, and by an epitaxial layer of opposite impurity back-biased with respect to the parent substrate. One extrinisic way is by deposited thin-film resistors on top of the substrate.

Anodized films of tantalum, titanium, or aluminum can provide highly precise resistance values. Initial deposit of these metal films is relatively thick and is easily formed by vapor plating and vacuum-deposition techniques. After deposition, the metal film can be trimmed to a precise value by anodizing the outer surface of the metal film to its oxide which is an insulating semiconductor. A high degree of control of the remaining metal film thickness can be obtained. Resistance films in the 10 to 500 ohms per sq cm range can be obtained with $\pm 1/4$ per cent reproducibility. Accurate layout of these resistance films is achieved by photoresist techniques. The unanodized film can be utilized to form conduction elements.

Tin oxide films have reached sheet resistance values of over 5000 ohms

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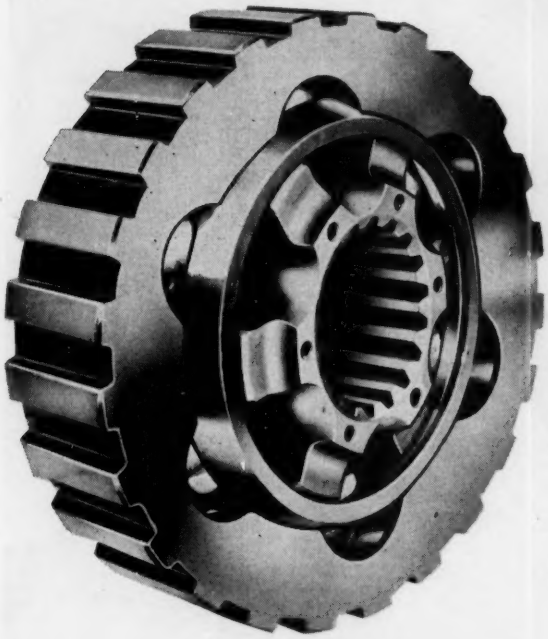

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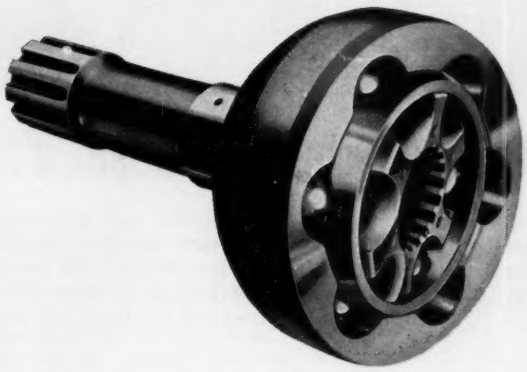

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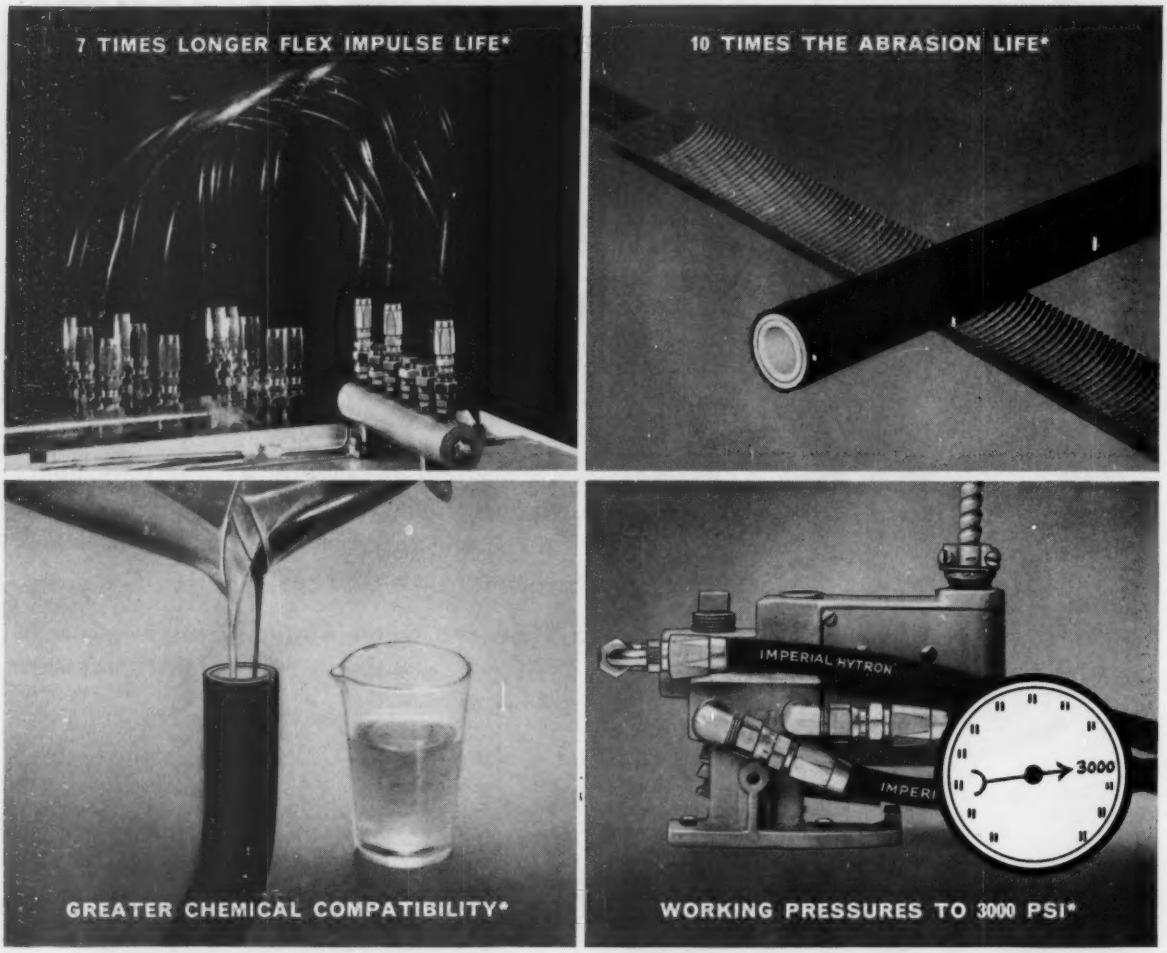

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per sq cm. With conventional resistance patterns, values up to 1.0 megohm can be achieved. The films are produced by hydrolysis.

Indium oxide films have been produced by a two-step metallizing-oxidizing process involving a vacuum deposition of pure indium in a low-pressure atmosphere followed by low-temperature thermal oxidation for several hours. This low temperature technique has application where higher temperature would damage other thin-film functions.

Nichrome films can be evaporated directly onto clean substrates by volatizing the alloy from a tungsten heater. These films show excellent adhesion when substrate surfaces are heated to 300 C. Nichrome resistance films can be reproducibly deposited and show relatively high stability on standing. They possess an average temperature coefficient of resistance of 6×10^{-5} ohms per ohm per deg C over the temperature range −50 C to 150 C.

These films have low resistivities which limit their application to 500 ohms per sq cm. In addition, the surfaces of unencapsulated Nichrome films are prone to a certain amount of corrosion and oxidation.

Bulk resistivity makes use of the gross geometry and parent material of the semiconductor substrate. It is easily controlled but is suitable only for relatively low values of resistance based upon maximum usable resistivity of approximately 500 ohm-cm. Since bulk resistivity of 500 ohm-cm is not compatible with present semiconductor base or collector technology, the most compatible value is between 10 and 30 ohm-cm. Bulk resistivity has the additional handicap of a complicated temperature coefficient.

Diffused back-biased regions cover the class of resistors formed by transverse conduction within a thin diffused back-biased layer of semiconductor. They cover a wide range of values and have additional advantages in their possible range of temperature coefficients. By control of the diffusion profile, it is possible to achieve positive, negative, or substantially zero temperature coefficient at room temperature. The difficulty in using diffused resistors in practical circuits lies in their great sensitivity to the back-biasing voltage.

Epitaxially-grown resistive layers can form resistive regions with useful characteristics. The method is similar to diffused back-biased resistance, but the epitaxial process promises better control of junction characteristics. The epitaxial resistor requires a compatible masking technique during layer growth.

Capacitance

Capacitance may be provided intrinsically by reverse-biased semiconductor junctions, by self-biased junctions, or extrinsically by deposited thin-film capacitors using gold or some other conducting film as a counterelectrode.

Anodized metals, such as tantalum, titanium, aluminum, or niobium can form the lower conducting layer and dielectric of deposited thin-film capacitors. After the desired thickness of dielectric has been formed, a counterelectrode of some conducting material is deposited to complete the capacitor. Ratings of 5.0 v-mfd per sq cm at 50 per cent breakdown voltage are now state-of-the-art.

Deposited metal-oxide glasses can be sandwiched between deposited conductors to form an alternative thin-film capacitor. Here the dielectric constant is much lower than other anodized dielectrics. But the use of low-melting silicate-type glasses avoids some of the problems of the anodized capacitor process.

Deposited ferroelectrics offer attractive possibilities as dielectrics for thin-film capacitors. Chief attraction is a dielectric constant for barium titanate three orders of magnitude greater than that for silicate-type glasses. Such a dielectric might also have important contributions stemming from its nonlinearity and polarizable nature. The chief disadvantages appear to be limited operating range of temperatures and instability of electrical properties.

Diffused back-biased junction capacitors depend upon the depletion layer as dielectric and, for step junctions at low voltages, can provide on the order of 1 v-mfd per sq cm. However, since the width of the depletion layer varies with the magnitude of

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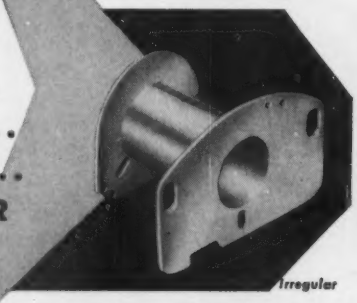

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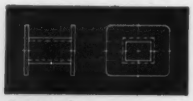

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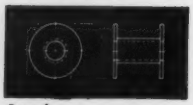

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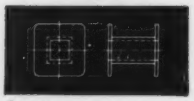

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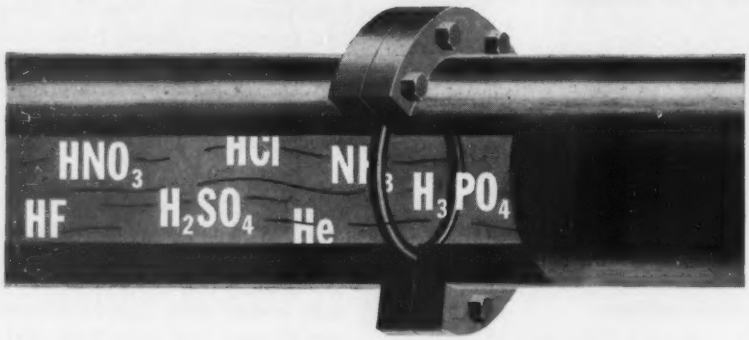

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*Patents 2,809,269; 2,837,360

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the reverse bias, such capacitors are electrically alterable with the magnitude of their effective capacitance depending on their bias.

Reverse-biased junctions act as capacitors whose value depends on the junction area and on the width of the depletion region at the junction. In turn, this width depends upon the impurity concentration gradient on each side of the junction, and upon the reverse voltage applied across the junction. Since the normal diffusion process produces a graded junction, capacitors formed by diffused junctions tend to have lower values of capacitance at the same bias than either alloyed or epitaxially grown junctions.

If current flows parallel to the junction outside the depletion region, the bias on the junction will not be everywhere the same. The result can be useful in circuits where a small capacitance is needed to bridge a load or coupling resistor.

Alloyed back-biased junction capacitors tend to have a much steeper impurity gradient across the junction on one side while maintaining practically the impurity concentration of the parent substrate on the other. Approximation to a step junction is much better than in the diffused case, and much higher values of capacitance at low reverse bias are possible. Because of the relatively low impurity concentration of the substrate, the total depletion layer is very nearly as wide at large values of reverse bias as in the diffused-junction case.

Epitaxial back-biased junction capacitors hold promise of the ultimate attainable in reverse-biased junction capacitors. In addition to being more amenable to control than the alloy process, they are able more closely to approximate the step junction from high impurity concentration of one type to high impurity concentration of the other. They should be capable of having the maximum capacitance, at low values of reverse bias, of any junction capacitor, and their voltage dependence should be more predictable.

Thermal oxidation on the surface of a semiconducting substrate can provide the dielectric for a hybrid type of capacitor in which one plate

is the semiconductor substrate and the other plate is a thin metallic film.

Where precise and voltage-stable capacitors of less than one microfarad are needed, deposited thin films of tantalum, titanium, aluminum, or niobium can be anodized with good control. High-voltage or nonpolar capacitors with small values of capacitance can be fabricated reliably, using silicate-glass-type dielectrics sandwiched between metal film electrodes. Voltage-variable capacitors or noncritical coupling capacitors can be formed in semiconducting substrates by back-biased junctions.

Inductance

Inductance is the most difficult to obtain of all the basic circuit parameters. Major difficulty is the requirement of a volume for the storage of magnetic flux. Furthermore, the coupling of energy to the volume poses the requirement of a coil that is not easily achieved by deposited film techniques.

Deposited nickel-iron films are among the extrinsic means available for storing energy resulting from the flow of current. Deposited nickel-iron films of 82 to 18 per cent composition and 1000 to 4000 Angstroms thickness have been used for storing energy for logical matrices and as small-value low-frequency inductors.

A requirement is the presence of a magnetic field during the deposition process to orient the magnetic anisotropy. Unfortunately this limits the magnetic film configuration to simple forms.

Deposited ferrites have possibilities as a second extrinsic technique for obtaining inductance. Glass, which is a mixture of metal oxides, is currently being deposited by the pyrolytic decomposition of suitable metallic-organic esters. Since ferrites do not have the same magnetic anisotropy as thin nickel-iron films, no magnetic field is needed upon deposition, and the form factor is not limited as it is with metallic films.

By proper masking methods, it is possible to form thin-film solenoids which surround such deposited ferrite materials and provide a means

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for coupling energy into and out of the material. Ferrite materials possess variable permeability which is a function of the applied dc magnetic field, and this can provide a control element for ac magnetic flux. Such variable inductors can serve as tuning or control elements.

Air core geometries are suitable for rf coils and other high-frequency small-valued inductors. It is possible to deposit "air core" pancake-type windings of thin-film conductors. When associated with thin-film insulators of low dielectric constant, the pancake-type winding can be formed in multiple layers to increase the total inductance of the element.

Inversion of capacitance by active-element networks is among the intrinsic techniques for obtaining inductance. Field effect semiconductor devices can provide an impedance inversion function.

Ferrite substrates provide the possibility of using a single or multiple-aperture ferrite material both as an inductive core and as a substrate for other elements. The coupling to the ferrite can be achieved by thin-film conductors. These elements, because of the dependence of their permeability on the applied field, can serve as a means for controlling magnetic flux.

Inductance diode is another intrinsic approach to the problem of providing inductance. The maximum effect is found with alloyed or near-step junctions in which the injection efficiency is close to unity. Chief difficulty in measuring or applying the observed inductive behavior is the instability of the inductive effect, both with current through the device and with temperature.

Special Networks

A few basic circuit parameters are of a hybrid nature and do not fall logically into any of the initial ten parameters.

Deposited distributed rc networks are among the extrinsic examples of functions that cannot easily be duplicated by lumped constant circuits. A simple example of this is an anodized tantalum resistor upon which has been deposited a counterelectrode of gold or some other metal.

Each part of the resistor has a capacitive relationship through the anodized dielectric to a unipotential conducting plane. The result is a series resistance with distributed capacitance acting all along its length.

Deposited lc networks are in the same class of difficulty as ordinary thin-film lumped inductance. About the only simple example is the pancake air core coil deposited as the counter-electrode of a deposited and anodized tantalum capacitor.

Transformer-like thin-film configurations have been proposed but both distributed lc and thin-film passive impedance transformation for integrated circuitry are in the early experimental state.

Diffused back-biased rc networks are similar to the thin-film extrinsic kind except that they are voltage sensitive as to their capacitance and sometimes even their resistance. If the current-carrying diffused layer is thin enough, or if the back-biased junction is between the parent substrate and a thin current-carrying epitaxial layer, variation of the reverse-biasing voltage will affect both the series resistance of the thin layer and the shunt capacitance to the substrate. Such a configuration can form a tuning unit in a phase-shift oscillator or feedback amplifier.

Bulk resonance effects, such as the piezo-electric resonance of specially cut quartz crystals, normally occur in other than semiconducting substrates. In the case cited, mechanical motion of the crystal would probably be disastrously damped by using it as the substrate for other circuits. It is conceivable that thin-film circuits could be laid out entirely along nodal lines.

Active impedance transform networks cover a wide field. Their scope extends from the impedance transformation characteristics of ordinary non-integrated devices to vague and esoteric proposals for active delay networks. By definition, the functions included in this category do not in general exist in a one-to-one correspondence outside the solid state.

Active Elements and Substrates

Active semiconductor elements in-

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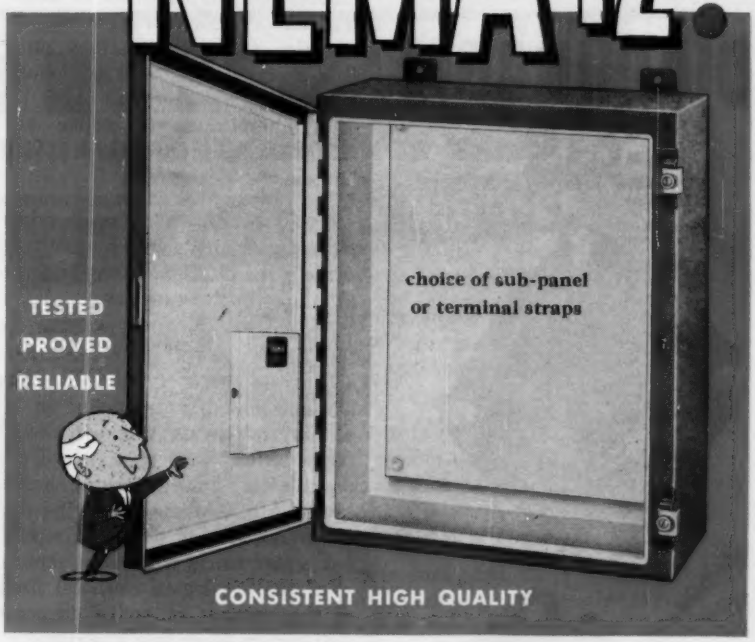

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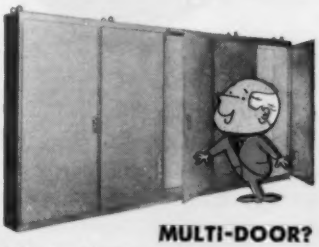

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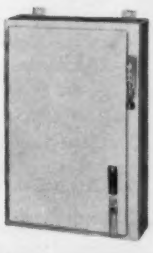

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clude the logic diode, the breakdown or zenith diodes, various multilayer diodes, the mesa transistor structure, the flat or oxide-masked mesa, the unipolar transistors, various other field-effect devices, and compound transistor-like elements. The list of non-semiconductor active elements includes ferromagnetic and ferroelectric elements.

Vapor deposition of semiconductor active elements on a passive substrate is the most important extrinsic technique in this category.

To date, no one has reported on the deposition of large-area nondegenerate single-crystal thin films of semiconducting material on an insulating substrate. When this technique is fully developed, it will be possible to build complex active functions on either active or passive substrates. One of the most important consequences will be the removal of the topological-electrical limit to the number of active elements that can be built into one semiconductor substrate.

Vapor deposition of nonsemiconductor active elements on a passive substrate can make useful many previously overlooked solid state effects. Both ferroelectric and ferromagnetic materials are unique in that certain of their basic properties, such as dielectric constant or permeability, can be readily changed by the application to the material of an electric or magnetic field of the proper magnitude. This property has been utilized in microcircuits for the purpose of circuit tuning.

Appliqué of active elements has been the universally used extrinsic expedient, since thin-film semiconductor active elements do not yet exist on insulating substrates. The active elements are attached to passive substrates to make a hybrid structure.

They may be conventional or special microminiature elements in cans with leads brought through the passive substrate and soldered, or they may be unencapsulated or self-encapsulated devices mechanically and electrically affixed on the passive two-dimensional substrate.

Conventional active-element design can be transferred directly to in-

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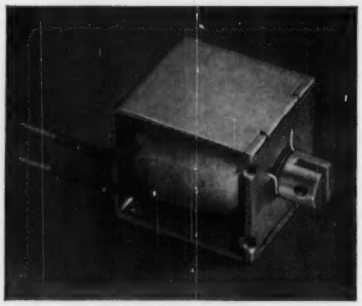

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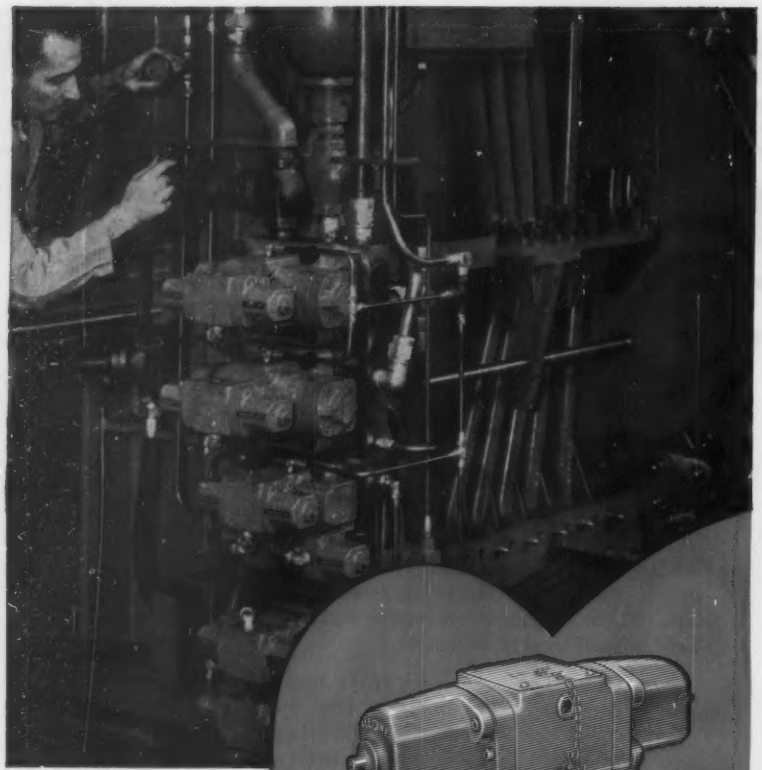

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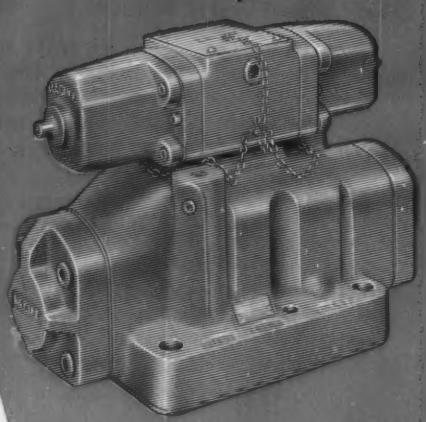

6 RACINE

Directional Control Valves guide hydraulic wire-forming operations of this machine

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HYDRAULICS DIVISION

tegrated circuits. Intrinsic techniques for creating active elements within semiconductor substrates include: Doped or rate-grown junctions in crystals as pulled from the melt, alloyed junctions, diffused junctions, vapor-grown junctions as epitaxially oriented overgrowth, and hybrid junctions.

Epitaxial techniques of growing silicon layers on silicon parent stock are among the most promising possibilities in the area of three-dimensional circuits.

The epitaxial process permits a number of desirable improvements over conventional active-element technology.

The substrate can now be a lower resistivity than could be tolerated when it had also to form the collector junction of active elements. Large-area step junctions are now much more nearly a reality, and the only diffusion effects are those occurring at the junction while the epitaxial layer or layers are being grown.

Form controlled growth currently pertains to ribbon crystal. The basis of this development is the ability to control the shape and structure of a growing semiconductor crystal as it is drawn from the melt.

Ferrite substrates offer a unique method of introducing an inductive element into the circuit. The requirements of such a substrate are those which must be met by any substrate: Surface smoothness, compatibility of thermal expansion and thermal conductivity with other active elements, and physical strength.

Use of a magnetic substrate imposes additional requirements. For inductive purposes a low-loss, high permeability material would be required, suitable for use at the frequency of interest. The temperature coefficient of permeability might be important where large fluctuations of the ambient temperature are anticipated.

The geometry of the substrate would depend upon the method used to couple the magnetic field into the circuit. One method consists of laying down the coil as a thin film on the surface. Another consists of providing holes in the substrate through which, or around which,

Circle 318 on Page 19

wires can be wound.

Encapsulation

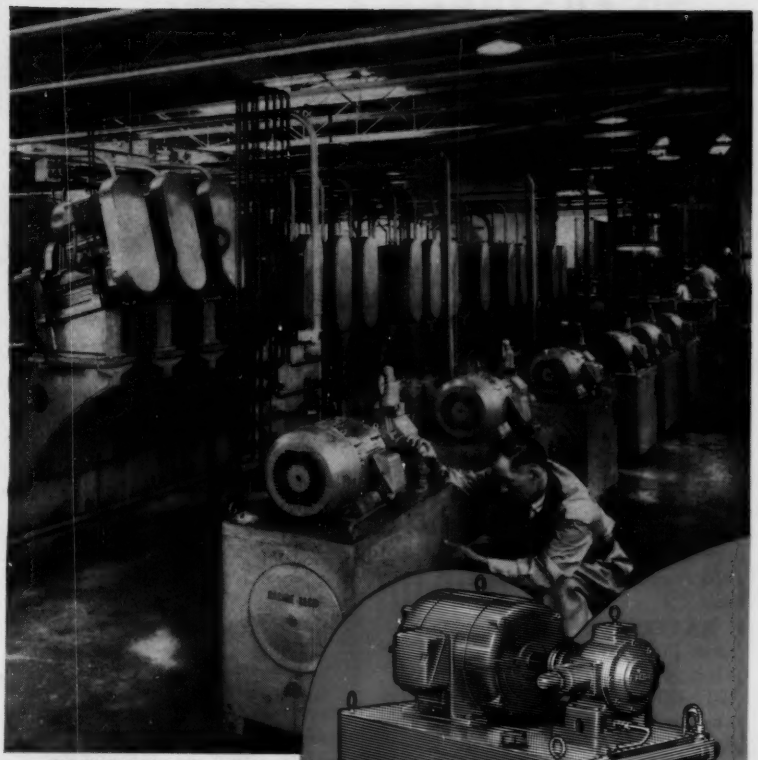
Achievement of desired performance, control, and reliability of semiconductor active elements, and to a lesser extent passive components, is dependent upon reliable and well-founded solutions to the protection of surfaces from the migration of contaminants in the ambient. These include moisture, radiation, and many other forms of contamination.

Hermetic seal has been the most widely used means of protecting semiconductor devices from contamination. A number of companies have made great strides, however, in developing other means of encapsulation, so the hermetic seal should be considered only as a temporary expedient.

Low-melting inorganic glasses have shown remarkable success in improving device performance and reliability. The glass may act as an ion getter in cleaning up surface contaminants and it protects against 100 per cent humidity for over 10,000 hr. Protective films can be deposited from the vapor phase over large surface areas. Application is limited, however, by the facts that these glasses may be soft at room temperature, that sulphur in the glass reacts detrimentally with certain thin-film materials, and that thermal expansion in mating with lead materials may cause difficulties.

Inorganic film pyrolysis offers a number of advantages. It is free from pinholes. It has high dielectric strength, high chemical and physical durability, low volume permeability to moisture, and it requires only low device temperature during encapsulation.

Accelerated thermal oxidation is a moderate temperature reaction, carried out at atmospheric pressure, which can form a completely protective glass-type layer by conversion of in situ material. This process applies only to material capable of being converted to glass. In the self-encapsulation of a silicon device, therefore, the process leaves the leads or contacts untouched. This feature has advantages for straight device fabrication but is of restricted appli-



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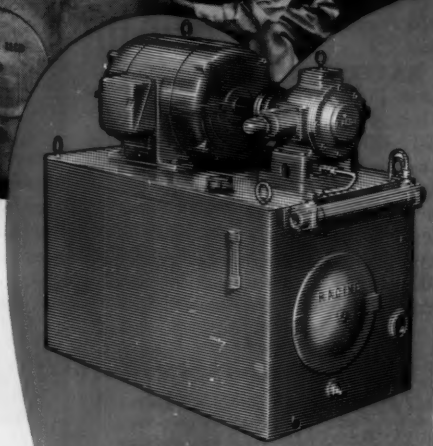

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Here is a check list for comparison of indexing mechanisms. "Price" is shown in its order of consideration.

1. BACKLASH—None? Some during the dwell or index or both? *Any* backlash during *any* part of the cycle results in wear-causing vibrations and shock loads . . . *The Ferguson Drive maintains zero backlash at all times.*

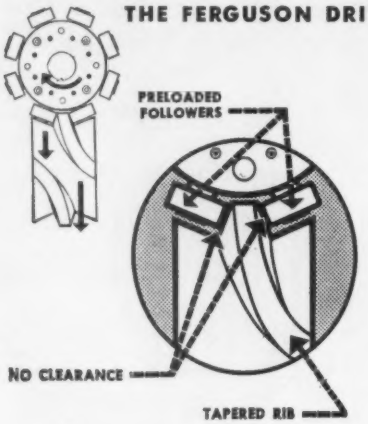
2. RATED LOADS—What is the rated life and under what load? What is the average follower life (B-10 life)? The Ferguson Drive is rated at maximum precision for at least 8,000 hours operation and with an average follower life of 90%. Replacement of the followers renews the life of the Drive for another 8,000 hours. Ferguson cams never wear out under rated loads.

3. JOB SUITABILITY—Can the acceleration characteristic be preselected according to job requirements or is it inherent in the mechanism or limited by the manufacturer? Acceleration of the Ferguson Drive can be chosen after an application evaluation to provide optimum operation.

4. INDEXING ACCURACY—Are time-consuming shot pins necessary for precision? . . . They soon wear and lose accuracy. The Ferguson Drive is positive locking and locating for extreme precision without shot pins.

5. FIRST COST vs. TOTAL COST—Now consider the higher production rates, better quality and much lower maintenance costs the Ferguson Drive gives you. Determine the *total cost* of the various indexing mechanisms. The Ferguson Drive has proved out . . . And you're on the way to building more profitable production equipment.

THE FERGUSON DRIVE



Cam features a tapered rib along which two standard cylindrical followers roll without clearance . . . *maintaining zero backlash during index and dwell.* While in the dwell or "work" position a straight portion of the cam rib locks the hub positively, without auxiliary locating or locking devices. *Extreme precision is inherent,* even at speeds as high as 2,000 indexes a minute!

CATALOG NO. 161 gives complete design data on nearly 100 standard indexing mechanisms, over 150 index tables and various auxiliary items. Send for your free copy . . . There's one for every design engineer.

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cability where thin films and semiconductors are combined.

Surface stabilization is an attractive possibility involving the deliberate addition of something to the surface of an active element which ties up all the possible loose ends and leaves the surface indifferent to subsequent contamination.

Mechanics

The mechanics of circuitry include form factor, masking, thermal conduction, access, and interconnection.

Form factor includes the size and shape of the substrate. It must take into account such things as heat removal, replaceability, accessibility for test, and position of leads. The initial form factor must allow for hermetic seals. A second step will probably be individual surface passivation or self-encapsulation with a number of related circuits in one can for protection. Ultimately, surface passivation will probably also constitute physical protection, and the individual circuits will be entirely self-encapsulated.

Masking is chemical insulation during the fabrication process. Chemical insulation refers to means of restricting the action of chemical etches and to masking portions of the substrate during evaporation, alloying, and/or diffusion. Metallic masks are a standard part of the art for evaporation as are the photoresist techniques and wax coating for etch protection. Recently added as standard practice are self-oxidation and vapor deposition of glass.

Interconnection covers the communication of circuits with associated equipment, and communication and supply of power between substrates.

Present efforts make use of ohmic connection, in some cases in the form of strips of conductor sandwiched between isolating ground planes. Such low impedance strip lines have a number of advantages from the circuit standpoint but the difficulties of removal and replacement of a particular circuit are formidable. Ultimately, other means of coupling (in addition to ohmic connection) will be used. Magnetic, capacitive, photon, and ultrasonic coupling are possibilities as means of conveying information and power.

Design

Progress in electronic circuitry depends on being able to fabricate and interconnect the basic circuit parameters. It also depends on knowing what techniques are compatible with which, what range of parameter values are realizable, what reliability individual circuit functions may be expected to have, and what control is possible in the constituent processes. It depends on the design of processes that fit into automated manufacturing methods. It depends on building into the manufacturing methods, from initial conception onwards, sufficient flexibility that the output of the product line can be changed easily and quickly. Finally, it depends on being able to accomplish all the necessary functions and operations economically.

Paper No. 2.1, "A Survey of Microsystem Electronics," presented at the joint IRE-AIEE-ACM Computer Conference, Los Angeles, May, 1961, 12 pp.

hydraulic

Vibration in Vertical Pumps

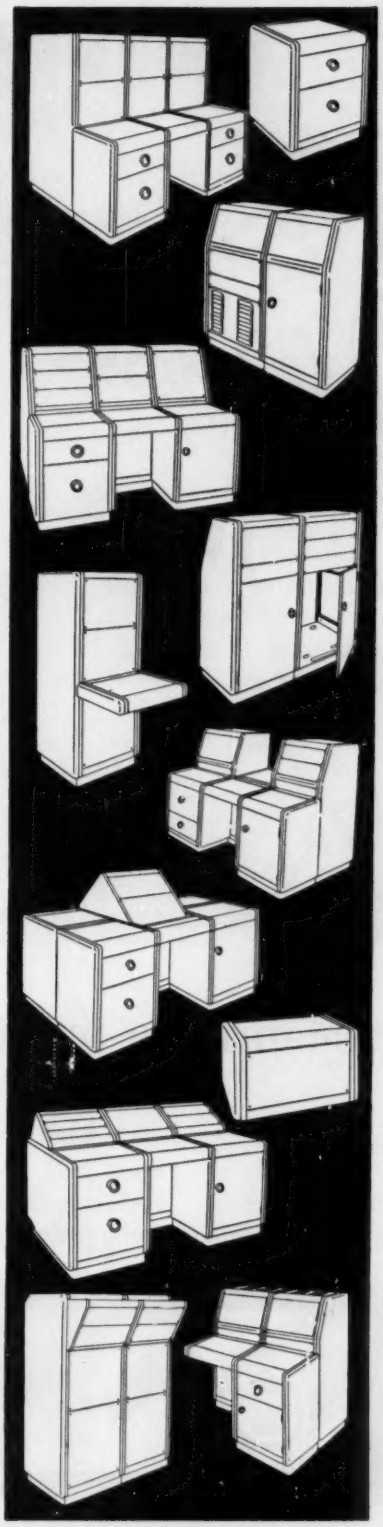
A. Kovats, chief engineer—pumps, Foster-Wheeler Corp., New York, N. Y.

Nature and importance of factors which cause serious vibration in relatively large vertical pumps. The most frequent sources of disturbing forces that cause vibrations of pumps are:

1. Unbalance of the rotating parts.
2. External vibrations transmitted by the foundation or by the pipeline.
3. Bearing vibrations.
4. Pressure pulsations.

Each disturbing force can develop vibrations in every part of the pumps, but generally the vibrations become excessive only if any of the disturbing frequencies coincide with or are close to the natural frequency of a part of the pump.

Bearing vibration results from the oil whip or from ball bearings. Although this problem exists mostly in horizontal shaft pumps and in oil lubricated bearings, it should be noted that identical phenomena occur also in water lubricated bearings and in vertical pumps.



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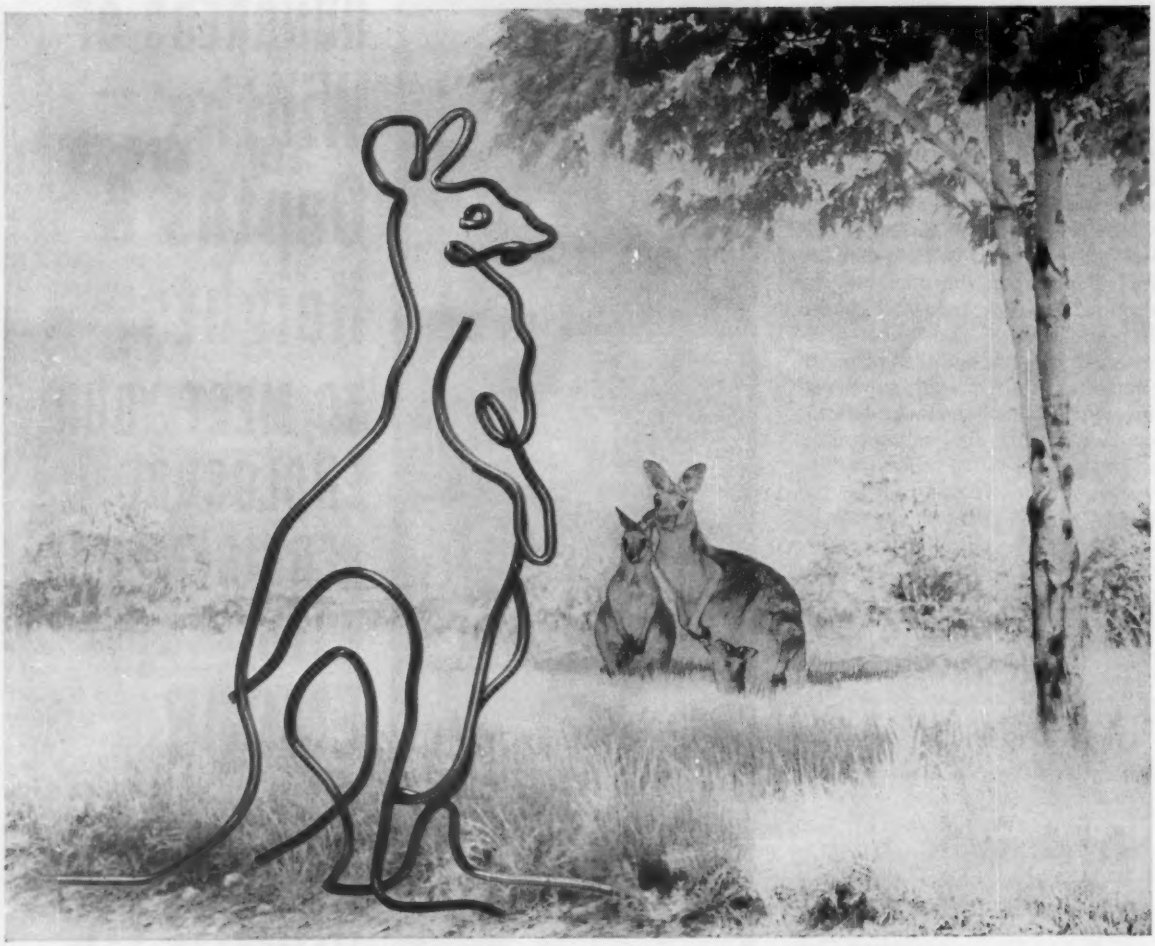
Circle 321 on Page 19



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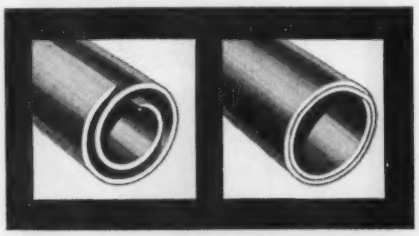

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Pressure pulsations, resulting from cavitation or from shocks produced on the tips of guide vanes, may also cause mechanical vibrations especially in the pipeline. In this paper, such vibrations are considered to be caused by an exterior source.

Misalignment is one of the most common sources of vibration, but it is the result only of poor workmanship, therefore, not a design matter.

In contrast to the horizontal shaft and vertical volute pumps, others, such as deep well pumps and vertical condensate pumps, are sometimes very long. The pump column is not at all rigid. Axial thrust, inner pressure, connecting pipes, and the damping effect of the water can cause a considerable change in the natural frequency of the rotating parts of the casing.

ASME Paper No. 61-HYD-10, *"Vibration of Vertical Pumps," presented at the ASME-EIC Hydraulic Conference, Montreal, Canada, May,* 1961, 9 *pp.*

electrical

Adjustable-Speed AC Drive System

C. G. Helmick, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa., and Ian M. MacDonald, Systems Control Dept., Westinghouse Electric Corp., Buffalo, N. Y.

Application characteristics of a drive system that uses frequency regulation to control drive-motor speed. With proper control, an ac motor can operate nicely over a wide range—20:1 or more—depending on the load characteristics of the system and the choice of frequencies.

"Adjustable-Frequency AC Drive System with Static Inverter," Westinghouse Engineer, *Vol.* 21, *No.* 4, *July,* 1961, *pp.* 123 *to* 126.

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IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

Westinghouse Engineer, P.O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa.

Small Size and Long Life Make G-E Glow Lamps Ideal as Indicators

There are over 60 General Electric glow lamps made especially for use as indicators in appliances, business machines, military equipment—wherever indicating devices are needed. They're small, rugged, usually low-cost, operate on standard AC voltage at low wattage and give off very little heat. All of which makes them ideal for use as indicators. Here are details on a few of them:

NE-2H lasts 25,000 hours on standard AC voltage,* only ¾ inch long, operates on just ⅛ watt, is a high brightness lamp and costs much less than a dime including an attached resistor (5 different resistors are available).

NE-2J another high brightness lamp with a 25,000 hour life* on standard AC voltage, operates on ⅛ watt, is less than one inch long, has a single contact midget flange base and will fit most standard indicator fixtures. This lamp is not available with attached resistor.

NE-45 has a 7,500 hour average useful life on standard AC voltage; operates on ¼ watt, is 1 17/32 inches long, has 30K resistor built into screw base and big electrode that presents a large glowing area when lit.

**With a 30K resistor.*

For detailed information on the 18 most popular General Electric glow lamps, write for bulletin #3-0193. General Electric Co., Miniature Lamp Dept. M-134, Nela Park, Cleveland 12, Ohio.

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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Silicone-Rubber Products

Properties and applications of a wide range of silicone-rubber products are outlined in Bulletin S901a. Included are definitions of silicone rubber, its advantages, uses, physical properties, and specific products manufactured of the material. Bulletin is illustrated by charts describing silicone-rubber properties, and by photographs. 12 pages. Dept. SI, Hewitt-Robins, Stamford, Conn.

Circle 501 on Page 19

Variable Transformers

Adjust-A-Volt variable transformers for bench or panel mounting, cased and uncased, ranging from 0.165 kva, 1.25 amp to 7 kva, 25 amp, plus motor-driven units, are covered in Catalog Section 1. Catalog contains illustrations, descriptions, electrical ratings, specifications, and dimension diagrams. Tabulation of specifications by unit is included in an engineering section which contains charts, graphs, circuit-arrangement diagrams, application data, and performance characteristics. 40 pages. Standard Electrical Products Co., 2240 E. Third St., Dayton, Ohio.

Circle 502 on Page 19

Metal-Sheathed Thermocouples

Metal-sheathed thermocouples provide a flexible solution to temperature-sensing problems when precision data is mandatory. Units are pictured and described in Catalog Supplement 161-A, and all specifications are included. Data on materials available are also furnished. 4 pages. Harco Laboratories Inc., 77 Olive St., New Haven, Conn.

Circle 503 on Page 19

Standard Plastic Parts

Daka-ware parts illustrated and described in Catalog 9 include knobs, handles, pushbutton knobs, gearshift-lever balls, meter cases, appliance feet and handles, pointer knobs, drawer pulls, and valve handles. Dimensional tables and specifications are included. 12 pages. Harry Davies Molding Co., 1428 N. Wells St., Chicago 10, Ill.

Circle 504 on Page 19

Control Valves

Series LB all-purpose control valves feature split-body design with seat ring that drops out when body halves are separated. Bulletin LB-4 gives details on construction and operation of the valve. Operation of the standard cylinder Conomotor actuator with Model J positioner and piston lip seals is described, and optional actuators and accessories are shown. Bulletin gives complete specifications and valve sizing formulas. 16 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle 505 on Page 19

Engine Controls

Series 46 and 56 controls automatically start and stop gas, gasoline, or diesel engines from the operation of a remote set of electrical contacts. Bulletin 601 pictures and describes the various types of these units. An accessories selection chart is included, as well as data on cabinets and enclosures. 12 pages. Synchro-Start Products Inc., 8151 N. Ridgeway Ave., Skokie, Ill.

Circle 506 on Page 19

Seals and Fasteners

Hexseals, Seelscrews, Seelbolts, Seelrivets, and Rubrglas Seel, in addition to transparent and flexible switch seals, power connectors with autodeflecting grounding blades, and other products, are included in Catalog 359B. Nylok fasteners, captive screws, and new molded silicone O-rings are also covered. Catalog gives dimensional drawings, part numbers, other technical data, complete specifications, and ordering instructions for each product. A. P. M. Corp., 41 Honeck St., Englewood, N. J.

Circle 507 on Page 19

Polycarbonate Films

Technical Report CDC-396 details the physical and electrical properties of Lexan polycarbonate films. Report compares extruded and solvent cast films and lists suggested applications. Summary of properties is included. 14 pages. Chemical Materials Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

Circle 508 on Page 19

Air Valves

Standard sizes of electromechanically operated air valves have been used in many aircraft and missile applications. Bulletin F-10539 includes performance-characteristic charts for aluminum and stainless-steel valves, as well as a pressure-drop nomograph to help choose the best valve for a specific job. Sizes range from 0.93 to 4.4 in. 4 pages. Barber-Colman Co., Rockford, Ill.

Circle 509 on Page 19

Casters and Wheels

Includes exploded-view diagram of a caster assembly, glossary of caster terminology, and a caster-selection chart, indexed by size and type of wheel and performance requirements. Contains descriptions, and technical information on casters and wheels in a wide range of styles, sizes, and capacities. Data on mounting arrangements, materials, and accessories are also given. Catalog 150, 48 pages. Hamilton Caster & Mfg. Co., 1700 Dixie Highway, Hamilton, Ohio.

Circle 510 on Page 19

Strain Gages

Covers 29 new Micro-Sensor semiconductor strain gages. Entire gage line is listed, with data on resistance, lengths, gage factors, curvature radii, temperature range, dimensions, and price. Includes information on recommended adhesives. 4 pages. Micro Systems Inc., 319 Agostino Rd., San Gabriel, Calif.

Circle 511 on Page 19

Stainless-Steel Screws

Unbrako KS 812 stainless-steel, socket-head cap screw is rated at tensile strength of 125,000 psi minimum at room temperature and for temperature range of −300 to +800 F. Application possibilities and dimensions for standard-diameter sizes No. 8 through ⅜-in. are reviewed. Table of typical mechanical properties gives tensile, yield, and shear strength, fatigue endurance, and stress-relaxation values for temperature of −60 to +800 F. Form 2734, 4 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 512 on Page 19

Printed Circuits

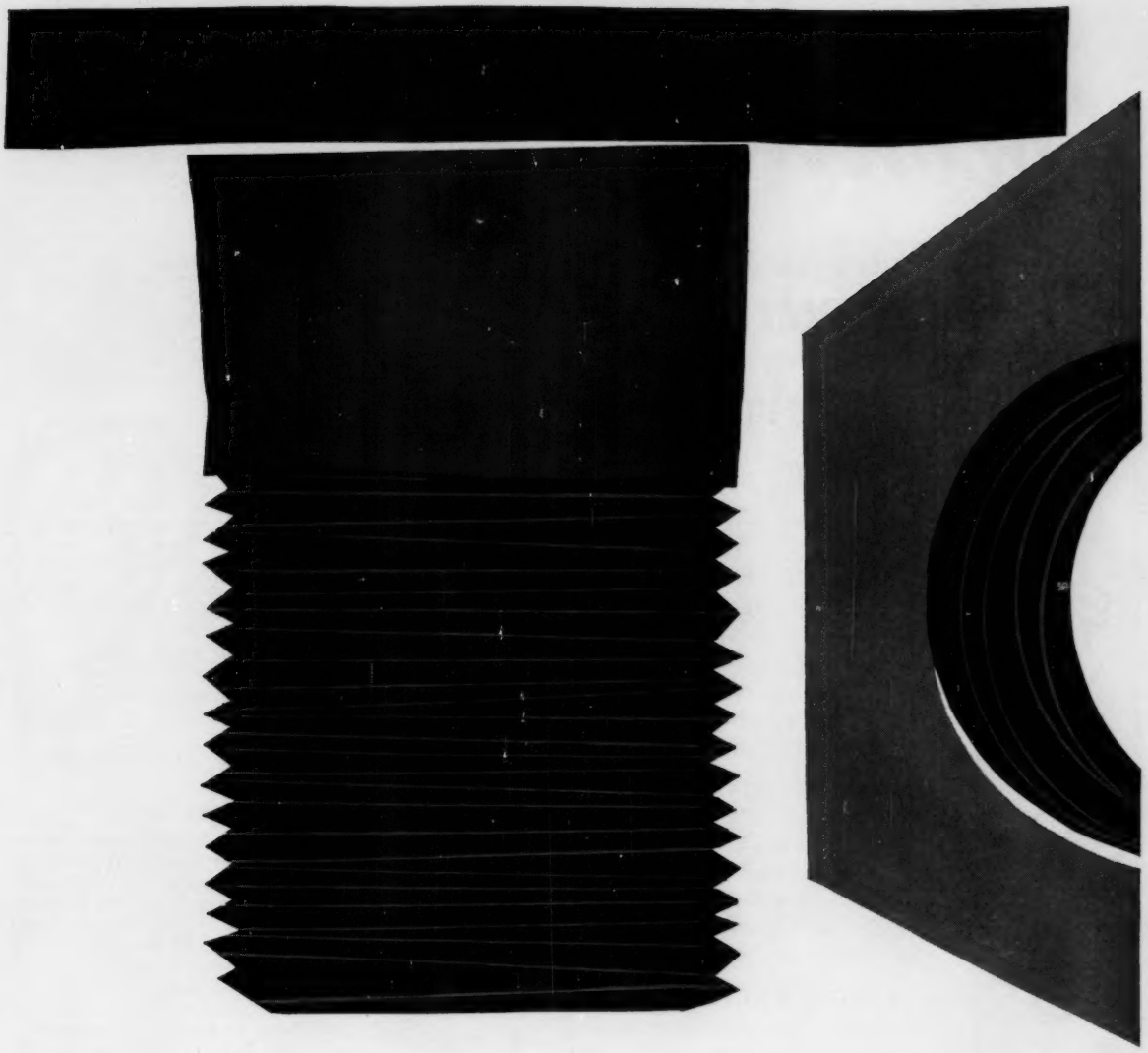
"Depth in Circuitry" provides complete specifications for all types of company's printed circuits. Includes descriptions of flexible, flush, and multilayer circuits, and Carte Blanche series of standardized plated circuit cards. 14 pages. U. S. Engineering Co., 13536 Saticoy St., Van Nuys, Calif.

Circle 513 on Page 19

Rhenium, Rhenium Alloys

Rhenium and its alloys have particular application in the electronics, nuclear, missile, aerospace, and electrical fields. Information on the fabrication, applications, price, and varieties of the material and its alloys is provided. Contains detailed data and charts on the relative advantages and properties of rhenium and its alloys. 12 pages. Rhenium Div., Chase Brass & Copper Co., Waterbury, Conn.

Circle 514 on Page 19



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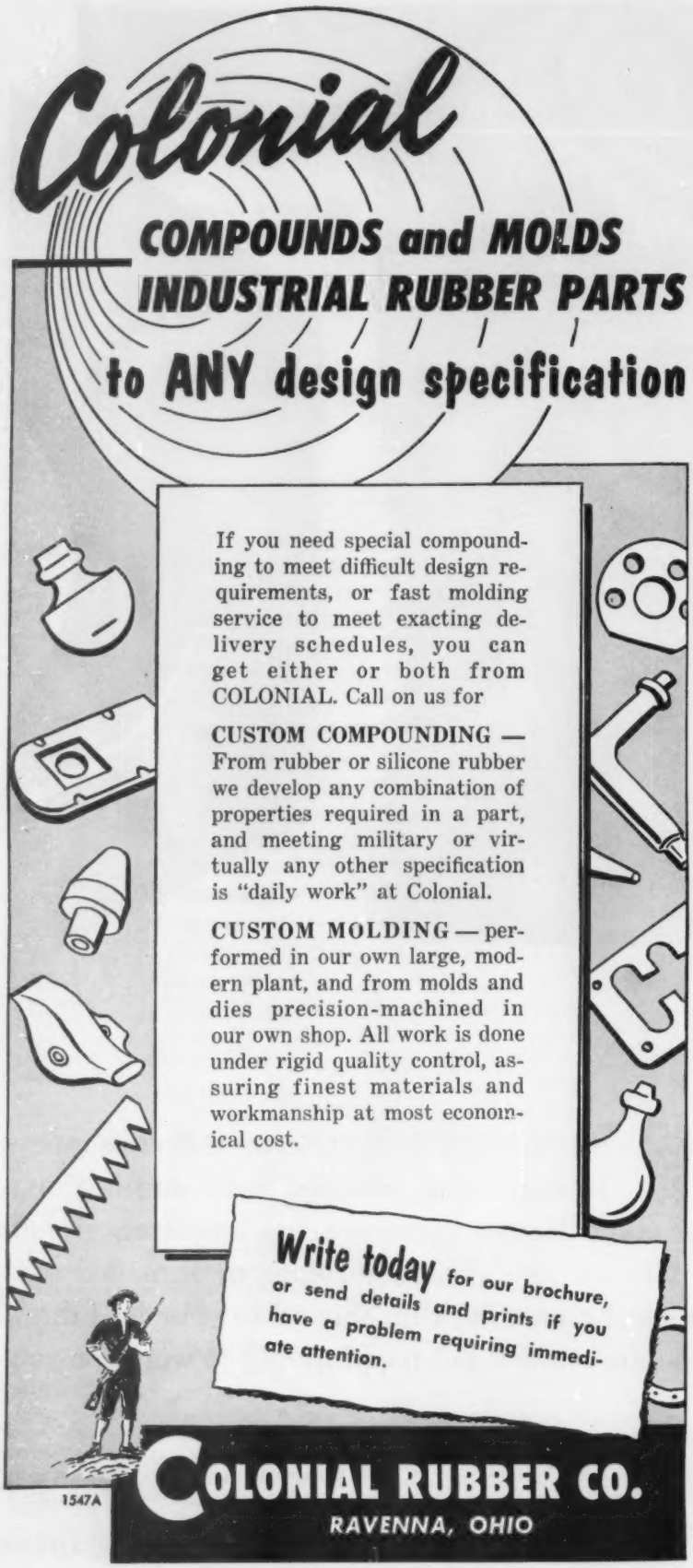
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HELPFUL LITERATURE

Pressure Transducers

Bonded strain-gage pressure transducers provide precision measurement of static and dynamic pressures to 60,000 psi. Bulletin 278 describes the design principle upon which these devices are based, outlines their functions and advantages, and explains how air-cooled and water-cooled models operate. Supplementary data presented include a typical performance specifications table; data sheet selection chart covering 14 basic models; table of cable and connector assemblies; and a list of mating connectors. 6 pages. Controls Div., American-Standard, 5900 Trumbull Ave., Detroit 8, Mich.

Circle 515 on Page 19

Ball Bearings

Standard unground ball bearings in single and double-race construction, plain or flanged design, have ODs from 1 to 4¾ in. Units have hexagon bores and load capacities to 1000 lb at 250 rpm. Complete data are presented for the bearings, suited for use in gravity and power conveyor rollers and as chain rollers in monorail turn sections for guiding chains. Bulletin B-61, 4 pages. Saginaw Products Corp., 68 Williamson St., Saginaw, Mich.

Circle 516 on Page 19

Adjustable-Speed Drives

MS and MCS adjustable-speed sheaves embody a design concept that eliminates freezing and sticking from fretting corrosion, allows sheaves to run indefinitely at one speed, and affords easy adjustment without sticking. MS sheaves rated at 2 to 15 hp and MCS units rated from 7.5 to 20 hp are described. Sure-Grip companion pulleys and sheaves, adjustable-speed belts, motion-control motor bases, and Quick-Slide motor bases are also covered. Bulletin 25103, 16 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

Circle 517 on Page 19

Precision Resistors

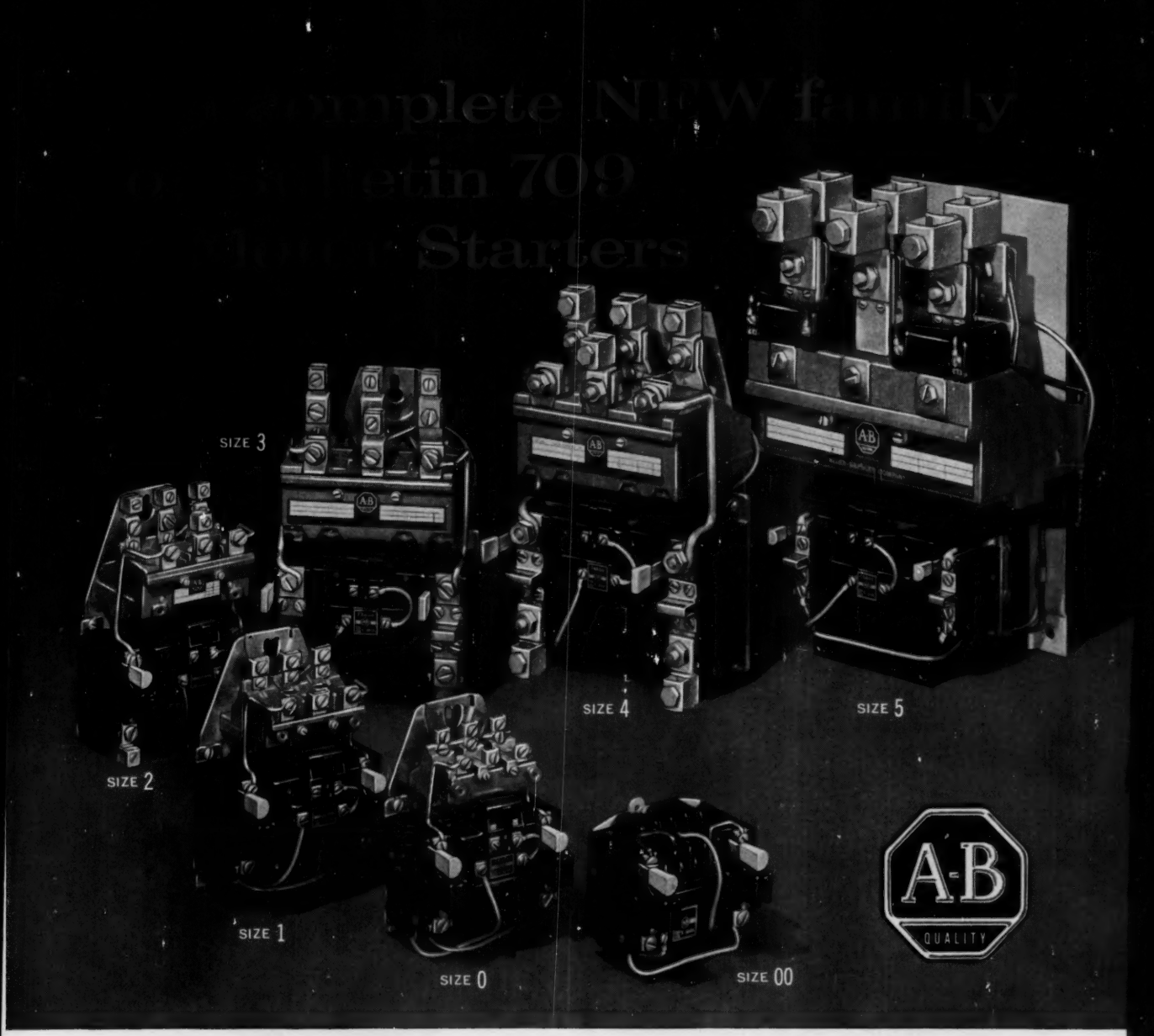
Molded metal-film precision resistors are for use in missile-guidance systems, electronic computers, radar equipment, instruments, and other electronic apparatus. Available in ⅛, ¼, and ½-w sizes, units are described in Catalog 50. Full data are included, and features and applications are listed. 6 pages. Ward Leonard Electric Co., Mt. Vernon, N. Y.

Circle 518 on Page 19

Plastic Optical Lenses

Thin, light-plastic discs, Bolsey Frenelenses, replace glass lenses in optical applications. Characteristics and results obtained with the flat-surface lenses are illustrated. Describes uses for such applications as projectors, viewers, shadowgraphs, cameras, field lenses, condensing lenses, and screens. Brochure 6104-10T, 8 pages. Stocker & Yale Inc., 366 Green St., Marblehead, Mass.

Circle 519 on Page 19



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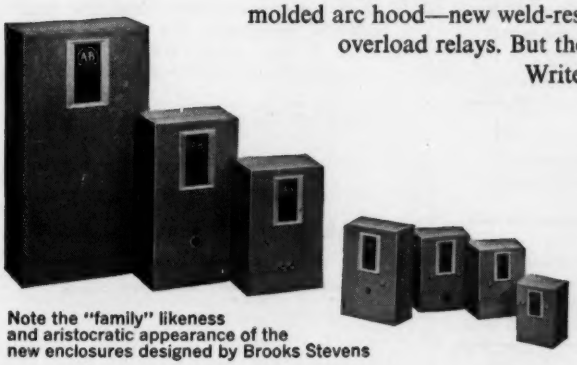

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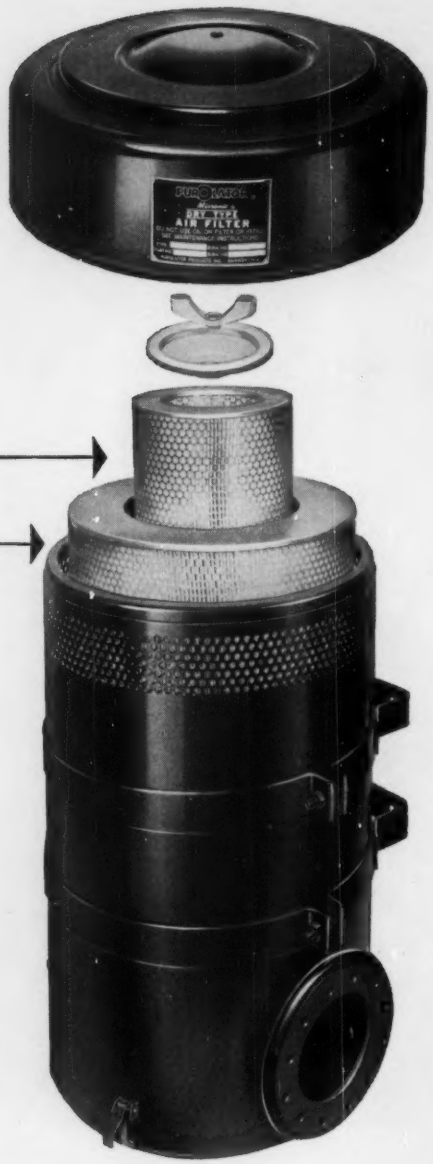
Circle 326 on Page 19

an element here

and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation



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Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Another big user-advantage is the way the two-stage design protects the engine despite accidental mishandling of the element. Even if the first stage element is damaged, the chance of harming the engine can be discounted when it is protected with the second stage back stop element. In addition, the second stage element lets the operator service the unit in the field, regardless of how dusty the conditions are.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic impregnated cellulose. This series of two-stage filters is rated from 450 to 1150 cfm, with exceptionally low initial restriction. Mounting straps, rainhoods and outlet adapters are available.

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Circle 327 on Page 19

Panel Instruments

Provides full specifications on standardized panel instruments available in choice of sizes, case styles, accuracies, pointers, scales, and ranges. Series 1900 units include ac and dc ammeters, milliammeters, microammeters, and voltmeters. Bulletin 01-113, 6 pages. Weston Instruments Div., Daystrom Inc., 614 Frelinghuysen Ave., Newark 12, N. Y.

Circle 520 on Page 19

Beryllium-Copper Strip

Beryllium-copper alloys, with tensile strengths to 215,000 psi have good formability, and good thermal and electrical conductivity. Complete technical information on two high-strength and two high-conductivity beryllium-copper strip products is available in four data sheets which show physical and mechanical properties, and provide information on methods of heat treating, forming, joining, and plating of beryllium copper. 16 pages. Brush Beryllium Co., 5209 Euclid Ave., Cleveland 3, Ohio.

Circle 521 on Page 19

Sprockets and Hubs

Illustrates and describes stock sprockets with stock shear-pin hubs and split-taper bushings. Tables of hubs, sprockets, and pins are provided, along with pictures and dimensional drawings. Also includes formulas for selection of shear-pin hubs and sprockets. Catalog CD-104-A, 4 pages. Browning Mfg. Co., Maysville, Ky.

Circle 522 on Page 19

High-Pressure Valves

High-pressure valves with capacities of 3000 and 6000 psi are made in globe, check, and relief types. Bulletin 280-B gives complete specifications for each type of valve, and line drawings illustrate nomenclature and general construction. 8 pages. Watson-Stillman Press Div., Farrel-Birmingham Co. Inc., 565 Blossom Rd., Rochester 10, N. Y.

Circle 523 on Page 19

Drafting Furniture

Presents complete specifications on 25 new Stacor-matic models in three basic groups: L series drafting table and reference-desk ensemble; D series single-unit drafting desk; and D-A series drafting desk with integral drawer unit. 4 pages. Stacor Equipment Co., 295 Emmet St., Newark 5, N. J.

Circle 524 on Page 19

Gasket Materials

Presents information concerning various styles of gasket materials available. Further data include choice of gasket material and correct design of a gasket. Detailed tables give information on the various materials available and uses for which they are best suited. Form AD-190, 24 pages. Garlock Inc., Palmyra, N. Y.

Circle 525 on Page 19

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Circle 328 on Page 19

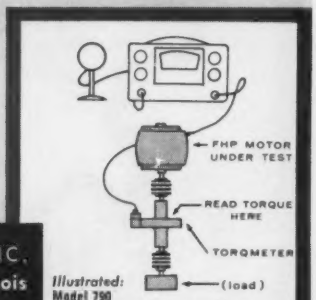
SENSITIVITY UNEQUALED

with FHP TORQMETERS

For ACCURATELY MEASURING Rotating and Static TORQUES of FHP motors, gear-train efficiencies, ball bearings, servos, synchros, potentiometers, hair springs, and many other applications and devices.

We invite your inquiry for complete information and prices . . . or, send your specifications and application needs.

Illustrated:
Model 783 OZ-TORQMETER
measures from .05 to 80 oz. — inch
Also available:
Model 782 GRAM-TORQMETER
measures from .25 gm-cm to 100 gm-cm
Model 784 POUND-TORQMETER
measures up to 200 lb. — inch
Model 781 GRAM-TORQMETER
measures from .05 gm-cm to 5 gm-cm



Illustrated:
Model 790
TACHLITE (STROBE-TACHOMETER)
Self-synchronizing, no drift.

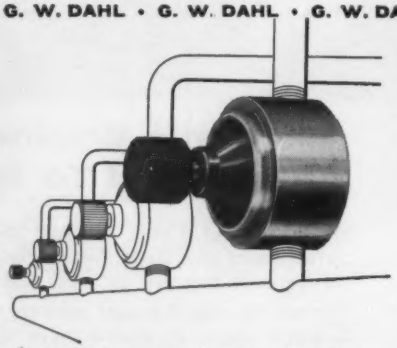
POWER INSTRUMENTS, INC.
7352 North Lawndale Ave. • Skokie, Illinois

NOTE: A few choice territories available for experienced representation.

Circle 329 on Page 19

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

LOW COST MINIATURE VALVE FOR TIGHT SHUT-OFF!



Dahl FLEXI-PHRAGM packless diaphragm valve ideal for instrument air and other gas and liquid services . . . for isolating and/or testing the pneumatic circuit in process control loops.

Resilient diaphragms (Neoprene, Viton A or Buna) withstand deformation by slurries, trapped impurities (unfiltered service) . . . still provide positive shut-off. Diaphragms resume original configuration when valve is opened and particles washed away . . . even after prolonged closures.

Rated to 500 psig and 180°F. Closing torque only 10 lb.-in. (as rated) in dead end service. Brass bodies with ⅛" or ¼" NPT connections. Panel mounts available.

REQUEST complete data on this low cost, high performance valve. G. W. Dahl Co., Inc., 83 Tupelo St., Bristol, R. I.

G. W. DAHL CO., INC.

SPECIALISTS IN COMPACT VALVES AND CONTROLS

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

Circle 330 on Page 19

HELPFUL LITERATURE

Vane-Type Fuel Pumps

Advantages of fixed-displacement, vane-type fuel pumps are pointed out. Includes photographs showing various pump configurations, typical fuel-pump performance curves, schematic diagrams, and a sketch showing principles of the vane design. Specifications for various pump models are given in table form. Bulletin A-5242A, 6 pages. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 526 on Page 19

Selenium Rectifiers

Line of certified selenium cells and stacks, and cartridge-type selenium rectifiers, are covered in Bulletin 400. Bulletin includes cutaway drawings showing features of its selenium rectifiers. Details of the vacuum vapor-deposition process are revealed in the drawings, as well as construction features of a typical selenium stack assembly and cartridge rectifiers. Tables give condensed electrical and mechanical specifications; typical operating characteristics are shown in curves displaying forward current rating levels and derating curves for raised ambient temperatures. 4 pages. Semiconductor Div., Syntron Co., Homer City, Pa.

Circle 527 on Page 19

Vacuum-Pump Selector

When heavy-cardboard slide rule is set at the required air flow in cfm at 0 psig, choice of rotary air-pump models is indicated. Setting pointer on opposite side of selector gives motor horsepower requirements and complete air flow characteristics over the range of 0 to 28 in. Hg vacuum or 0 to 30 psig pressure. Gast Mfg. Corp. 2318 Fair Ave., Benton Harbor, Mich.

Circle 528 on Page 19

Mesa Transistors

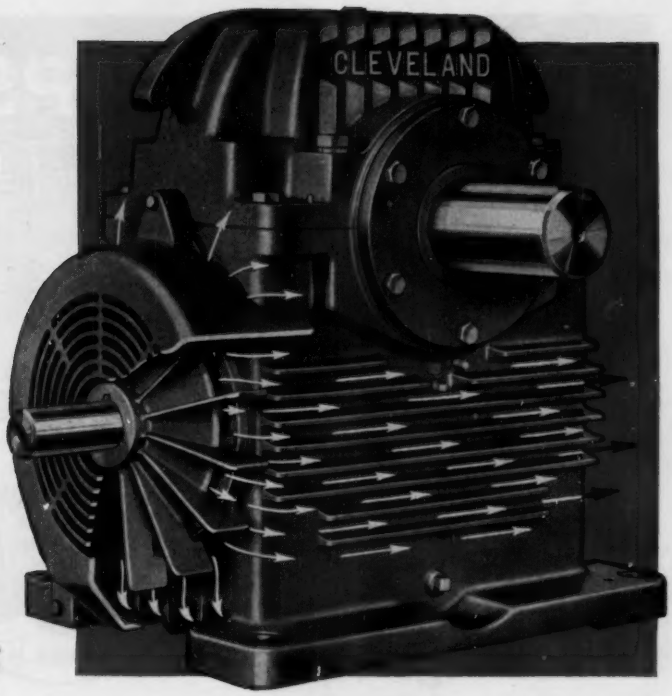
No. 2N834 and 2N835 silicon NPN double-diffused epitaxial mesa transistors are described. Includes data on ratings, switching characteristics, sizes, and electrical characteristics. Typical circuit applications are given. Bulletin DS 5015 R1, 8 pages. Motorola Semiconductor Products Inc., 5000 E. McDowell Rd., Phoenix 8, Ariz.

Circle 529 on Page 19

Numerical Control

Presents data about the machine-tool, numerical-control field, defines the meaning of numerical control, and explains the use of punched tape in machine-pool applications. Other subjects include: Where numerical control is used, programing tapes, standardizing punched tapes, and standardized programing. Also presented is the Flexowriter automatic-writing machine for punching and verifying eight-channel tapes for numerical-control applications. 32 pages. Friden Inc., 97 Humboldt St., Rochester 2, N. Y.

Circle 530 on Page 19



Fan cooling for Increased HP Capacity is Not New... *to users of Cleveland Speed Reducers*

As far back as 1944, Cleveland Speedaire Worm Gear Reducers (shown in both the announcement ad and cutaway photo below) were providing industry twice the load carrying capacity then available from standard worm gear units of equal frame size. Even then, it was *fan cooling* that did the trick—because fan cooling was and still is the most practical method of heat dissipation.

On the new, higher horsepower Cleveland's (shown in top cutaway photo), a small, specially designed fan—equally effective in either direction of rotation—is located on the worm shaft's input side. Fan size and design permit a smooth, more effective flow of air beneath, above, and around all sides of the reducer.

Mounting the cooling fan on the worm shaft INPUT end is a very definite Cleveland advantage for when the fan is mounted on the *opposite* side, a second oil seal is needed. This results in additional friction loss due to seal drag—and is another point where oil leakage could occur.

Remember, it was Cleveland design engineers who pioneered both fan cooling and centrifugal casting of bronze gears—and after sixteen years of rugged field usage in all types of industrial plants, have now incorporated these features in all units (from 3 to 12-inch centers) of the new standard Cleveland Speed Reducer line.

Get the story of these new speed reducers from your Cleveland representative, or write today for free 36-page illustrated Bulletin No. 410 that contains complete engineering information. Either way, you will get the answer to improved speed transmission—at savings of 50% or more on per horsepower cost!

A 1944 CLEVELAND AD "Announcing A Fan-Cooled Worm Gear Speed Reducer ... SPEEDAIRE."

CLEVELAND
Worm Gear
Speed Reducers

Cleveland Worm & Gear Division
Eaton Manufacturing Company
3270 East 80th Street • Cleveland 4, Ohio

Circle 331 on Page 19

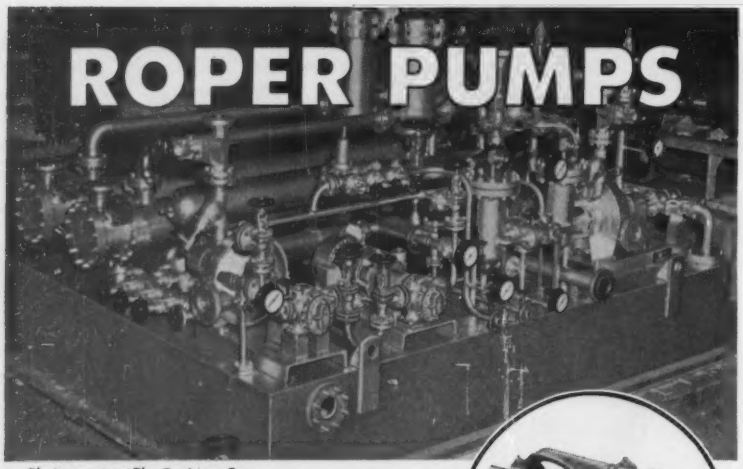
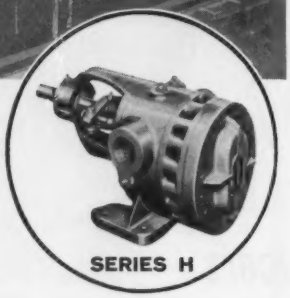


Photo courtesy The Engineer Co.



maintain lubrication of seals and oil bearings on large centrifugal compressor

• CAPACITY RANGE: 5-75 GPM • OPERATING PRESSURES: TO 1000 PSI

The complex lube system for this centrifugal compressor was designed by The Engineer Co. for the Elliott Co. and Blaw-Knox for Ashland Oil Co., using two types of Roper pumps as booster and main lube units. The Fig. 1H15 booster pumps handle 70 SSU viscosity SAE-10 lube oil at operating temperatures of 140°F, and deliver up to 17 gpm at 475 psi pressure. The two main lube pumps are specially modified Roper Series K units handling 76 gpm at 50 psi. Close cooperation with The Engineer Co. by Roper determined the pumps which would best serve the needs of this lubricating system. Special problems involving pump components for your equipment will receive this same skilled assistance by Roper engineers.

RELIABLE SERVICE AT HIGH PRESSURE

- **SPUR GEARS,** specially designed for high volume efficiency at high pressures, are hardened, ground, shaved, and perfectly balanced to operate quietly, smoothly.
- **DRIVE SHAFT,** separate from the drive gear, protects pumping gears from thrust load stress, preserving the axial hydraulic and mechanical balance of the gears.
- **ROLLER BEARINGS** and bronze wearplates are built for heavy-duty use, absorbing stress of heavy loads and continuous service. These parts are lubricated and cooled by liquid being pumped, and are easily, quickly replaced.

Contact your nearest Roper Dealer for specific pump information

Send for our new Series H catalog

ROPER HYDRAULICS, INC.

Dependable pumps since 1857
COMMERCE, GEORGIA

Circle 332 on Page 19

Weldable Strain Gage

Capable of continuous operation at 750 F and dynamic test to 1500 F, new weldable strain gage is described. Specifications, data on construction and installation, and graph of apparent strain versus temperature are included. Bulletin SG-1, 2 pages. Microdot Inc., 220 Passadena Ave., South Pasadena, Calif.

Circle 531 on Page 19

Premium Lubricants

Basic concept of molybdenum-disulfide additives employed to enhance temperature capabilities of lubricants is explained. Two pages of charts diagram the reduction of frictional resistance between moving parts. Includes sections on functional operation, physical properties, and practical application. 20 pages. Hercules Packing Corp., Dept. PL 1, 11061 Walden Rd., Alden, N. Y.

Circle 532 on Page 19

Roller Chain and Sprockets

Contains data on power-transmission plans and ideas. Engineering section provides 35 methods of chain adjustments on movable and fixed sprocket center drives, plus data on roller chains, sprockets, standard and custom conveyor attachments. Catalog 8, 106 pages. Acme Chain Corp., 821 Main St., Holyoke, Mass.

Circle 533 on Page 19

Molded Packings

Line of Palmetto molded packings for maintenance of presses, pumps, compressors, and other hydraulic and pneumatic equipment is presented. Provides assistance in selecting the correct packing for each application. Products included are Pyramid V-packing, U-rings, Kups, Pisto-Rings, and industrial class V-rings, U-cups, and O-rings. Also covered is a series of shallow-cross-section packings for shallow stuffing boxes. Catalog MP-361, 8 pages. Greene, Tweed & Co., North Wales, Pa.

Circle 534 on Page 19

Vinyl Resins

Presents data on Elvax resins, copolymers of ethylene and vinyl acetate designed for compatibility with parafin wax. Includes analyses, properties, blending procedures, and list of applications. Bulletin A-18749, 14 pages. Vinyl Products Div., Electrochemicals Dept., Wilmington 98, Del.

Circle 535 on Page 19

Miniature Potentiometers

Available in ranges from 0-10 to 0-5000 psia in one basic miniaturized configuration, miniature pressure potentiometers withstand 35g to 2000 cps without fluid damping. Models P104 and P105 pressure potentiometers are described. Bulletin 1045, 4 pages. Trans-Sonics Inc., P. O. Box 328, Lexington 73, Mass.

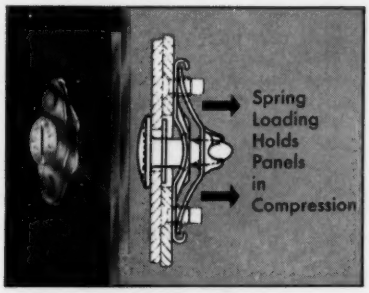
Circle 536 on Page 19

Quick-Opening Fasteners

Selecting Small Fastenings for Metal Closures

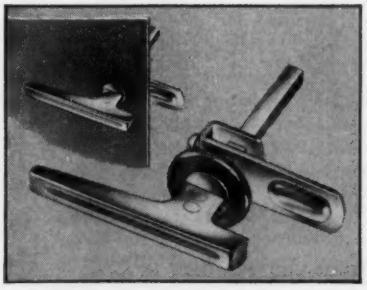
*"Use captive fasteners wherever feasible . . . Avoid the use of loose washers and loose nuts . . . Fasteners on equipment covers should be operable either with no tools or with standard hand tools"**

(John D. Folley, Jr. & James W. Altman, Research Scientists, American Institute for Research)



Quarter-Turn Fastener

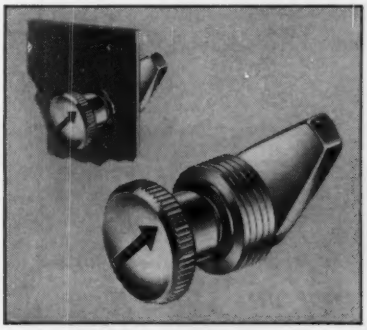
Lion Fasteners open and close with a ¼ turn, hold sheets tightly under the compression of a rugged spring. Quickly operated and fully retained in the outer panel, they are approved under U. S. Government military specifications. Stud and receptacle float for easy alignment and simplified hole preparation. Flush, oval, wing, knurled, ring, and key head styles available. Sizes—No. 2, No. 5, and High Strength for extra heavy duty.



Cabinet Latch

Just drill a hole, push the fastener stem through, and slide the special push-on clip into place. No welds, screws, bolts or rivets: the fastener is permanently installed in seconds!

Adjustable to any grip length or panel thickness, the pawl is fixed in place by a single set screw. The fastener's brightly finished knob is set off by a plated washer. Also furnished with screwdriver operated flush head.

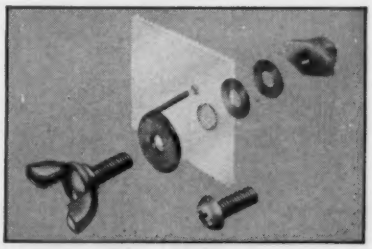


Spring Tension Latch

For fastening slide-out drawers and hinged panels the Southco Arrowhead Latch is recommended. It locks or opens with a quarter turn yet occupies less than ½" inside space.

Doors are held under spring tension—a push against the arrowhead knob relaxes this tension, allows operation with fingertip ease. Drill a single hole for installation—no fastening to the door is necessary. No striker plate is needed.

Pawl stop is eliminated—arrowhead shows at a glance exact position of pawl.



Adjustable Panel Latch

Small doors and panels can be fastened with greatest speed and lowest cost with the Southco Adjustable Latch.

The entire fastener is quickly installed through two holes punched in the door; no bolts or rivets are needed.

It operates with a quarter turn, requires no striker plate. An extra twist after the nylon pawl is engaged pulls up the door to form a seal and eliminate vibration.

Available with wing, knurled, or Phillips head.

Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Gives complete engineering data on these and many other special fasteners.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

* *Quotation from "Designing Electronic Equipment for Maintainability"; Machine Design, July 12, 1956.*

SOUTHCO FASTENERS
LION

Circle 333 on Page 19

LUBRICATION REPORT

(dry film coating)

Application: *Lock Part Pre-Assembly Lubrication.*

Problem: *Find a quicker, cleaner method of lasting lubrication.*

Solution: *'dag'® Dispersion 154 — diluted in equal parts with denatured alcohol.*

RESULT: *CLEANER, MORE UNIFORM, LONGER-LASTING LUBRICATION ON LOCK PARTS*

Cam retainers and disc tumblers used in American Hardware Corporation's padlocks are 1/2 by 1/4 inch brass stampings. Because of their small size, this New Britain, Conn. manufacturer has found dipping to be the most efficient method of lubricating them. Acheson's 'dag' 154 proved to be ideal for this operation. Its alcohol carrier quickly evaporates, leaving a permanent film of graphite on the parts. This microscopically thin film is deposited uniformly, adheres tenaciously, and will not rub off during lock assembly. Since it does not attract dust and discourages oxidation and corrosion of the brass parts, 'dag' 154 provides a longer, smoother operating life for the locks.

For more information on the advantages of Acheson dry-film lubricants in product design, send for your copy of Bulletin No. 435. Write to Dept. MD-81.

ACHESON — First name in solid lubricants for fifty-three years.

ACHESON Colloids Company

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Sales offices in principal cities.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

Circle 334 on Page 19

HELPFUL LITERATURE

Aluminum Casting Alloy

Precedent 71 is a high-strength, shock-resistant casting alloy available for use where high yield strength and low elongation are required. Bulletin describes the two forms of the material, and lists characteristics and applications. Also provides data on castings that must be dip or furnace brazed, polished or anodized to certain finishes, resistant to corrosion, or rough and finish machined. 8 pages. William F. Jobbins Inc., Aurora, Ill.

Circle 537 on Page 19

AC Gearmotors

Describes ac fractional-horsepower gearmotors, both in-line and right-angle designs, for operation on single and polyphase circuits at all standard voltages and frequencies. Lists gearbox specifications and includes drawings with approximate dimensions for both in-line and right-angle designs. Bulletin 1300G, H, 2 pages. Ohio Electric Mfg. Co., 5400 Dunham Rd., Maple Heights, Ohio.

Circle 538 on Page 19

Control, Torque Synchros

Data Sheet CS/TS-4-11-1 provides data on the rapid and correct selection of size-11, 400-cycle, Thru-bore control and torque synchros for servo applications. More than 25 typical characteristics are charted for transformers, transmitters, differential transmitters, and receiver transmitters. Schematic drawings, with dimensions, show body terminal block, spline, and other data. Wiring diagrams and terminal designations are also included. 4 pages. Vernitron Corp., 125 Old Country Rd., Carle Place, L. I., N. Y.

Circle 539 on Page 19

Resistance Alloy

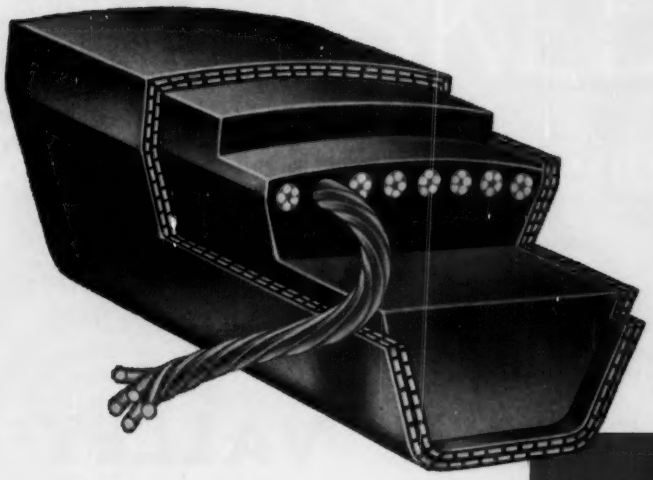
Describes properties and performance characteristics of Alloy 750, a low-growth, iron-chromium-aluminum resistance material developed for use as heating elements in small appliances and other devices where operating temperatures do not exceed 2050 F. Contains properties data, specification tables, recommendations for designing, fabricating, and welding coiled heating elements of the material. Bulletin 112, 8 pages. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

Circle 540 on Page 19

Fans, Air Washers

Describes how to handle corrosive fumes with fans, air washers, and exhaust systems of PVC. Includes details on line of unplasticized Type I, PVC centrifugal, tubeaxial, and utility fans, and air washers. Chemical-resistance data are tabulated for normal and high-impact PVC and various metals, covering all types of chemicals and their resistance ratings. Includes properties chart of PVC. Catalog F, 36 pages. Industrial Plastics Fabricators Inc., Endicott Street, Norwood, Mass.

Circle 541 on Page 19

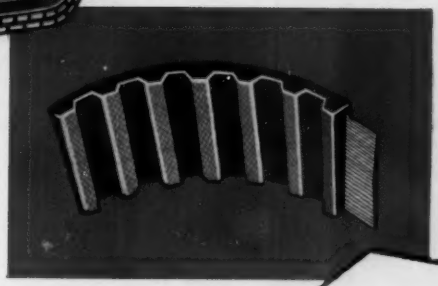


Need High Capacity In Compact Space?

DA 358 V-BELTS. This major design improvement in V-Belts brings you unprecedented compactness, high capacity and drive economy.

Chain and Gear Benefits with No Metal-to-Metal Contact?

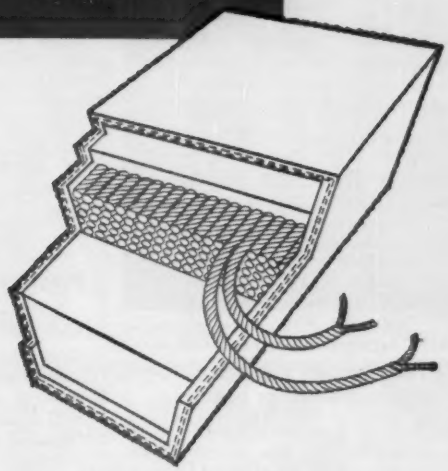
DA POSITIVE DRIVE BELTS. Revolutionary tooth-grip principle; no stretch; no constant lubrication. Highly versatile.



Whatever your V-Belt needs, DURKEE-ATWOOD *meets them*

What do you want in a V-Belt? You want consistent performance, long trouble-free life and full-rated power transmission. That means the belts must be made of the finest quality materials, with careful attention to engineering details, manufacturing processes and testing procedures. Durkee-Atwood V-Belts are made of the newest high tenacity synthetic fibres to assure length stability in storage. The exclusive Durkee-Atwood "Iso-Dynamic" Vertical Matching Machine eliminates the "sag error" that develops when V-Belts are matched on horizontal equipment. This assures equal power transmission from all belts on multiple drives . . . Look to Durkee-Atwood for *quality, service* and *savings ...the most complete line of industrial V-Belts.*

Look for the DA DURKEE ATWOOD *On Your V-Belts*



40% Extra Capacity in Regular V-Belts?

RED SHIELD MULTIPLE V-BELTS. Increased capacity at no increased cost. Available in oil and heat resistant and static dissipating constructions.

Top Performance in Variable Speed Drives?

VARIABLE SPEED BELTS. For constant performance. Abrasion-resistant cover; crowned cross section maintains stability under extreme loads.

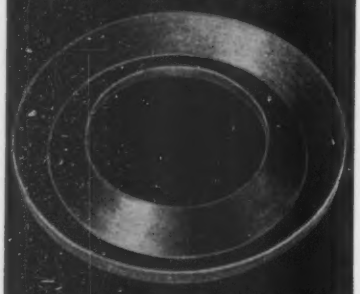
DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA

NOT JUST PACKINGS!

SPECIFY CHICAGO-ALLIS

FOR EXAMPLE VEE PACKINGS



- LEATHER—Wide variety of leathers and impregnants to accommodate a wide range of temperatures, pressures, and mediums.
- HOMOGENEOUS RUBBER—Natural and synthetic rubbers—especially compounded and processed for specific applications.
- COMPOSITION—Includes cotton and asbestos duck impregnated with synthetic rubbers, especially processed for type of fluid or medium and temperature and pressure conditions.

All Chicago-Allis packings are available with *anti-friction* impregnations or coatings.

Whether it is a problem of higher pressures, higher temperatures, extreme operating conditions, or unusual compounds or liquids . . . or just a matter of plain efficiency, economy, and dependability . . . there is a Chicago-Allis packing especially suited for the application. C-A products are used across industry . . . automotive, aircraft, home appliances, agricultural equipment, machine tools, and ordnance equipment. Just ask for the assistance of C-A engineers who are always available for counsel on your packing requirements.

SINCE 1880

FREE! New 16 page Packing Handbook WRITE FOR IT TODAY!

CHICAGO-ALLIS

MFG. CORP.

127 N. GREEN ST. CHICAGO 7, ILL.

Circle 336 on Page 19

HELPFUL LITERATURE

Vinyl-Aluminum Laminate

Contains a sample of Vynalate vinyl-aluminum laminate material and chips of each of 39 vinyl color-pattern combinations. Accompanied by technical data and use suggestions, samples demonstrate the seven categories of vinyl designs, in four to eight colors per design. Information on designs-to-order is also provided. 20 pages. Aluminum Co. of America, 720 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 542 on Page 19

Centrifugal Pumps

Illustrates and describes Type GBH close-coupled, end-suction centrifugal pumps. Included are cross-sectioned views, selection chart, dimensions, optional assembly positions, parts identification, limitations chart, and specifications. Bulletin 108, 6 pages. Aurora Pump Div., New York Air-Brake Co., Aurora, Ill.

Circle 543 on Page 19

Shell-Type Motors

Available in open, enclosed, or liquid-cooled ratings from ½ to 150 hp, shell-type motors provide accuracy and close tolerance to facilitate ease of assembly and correct fit with machine components. Mechanical and electrical properties, construction, motor selection, and ventilation are described. Bulletin 107, 4 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis.

Circle 544 on Page 19

Pressure Regulator

In new Type 10 pressure regulator, high-gain servomechanism permits use of downstream pressure for piloting, to provide accuracy of one part in 5000. Principle of operation is explained. Operating ranges, mechanical details, and performance curves for three standard models ranging from 2 to 120 psi are included. Bulletin LC, 100 4 pages. Lexington Controls Inc., P. O. Box 132, Burlington, Mass.

Circle 545 on Page 19

General-Purpose Relays

GR relays have simple, rugged construction and offer flexibility for making connections or mounting. Versatile enclosures and plate and latching versions are described, and large list of stock units is also incorporated. Bulletin 166, 4 pages. Ohmite Mfg. Co., 3653 Howard St., Skokie, Ill.

Circle 546 on Page 19

Hose, Couplings, Connectors

Dimensions and specification on standard lines of industrial and automotive hose, hose couplings, union adapters, and connectors are provided. Includes detailed drawings and cut-away photographs. 12 pages. Write on company letterhead to American Coupling Corp., 31739 Mound Rd., Warren, Mich.

AROUND THE CLOCK PERFORMANCE

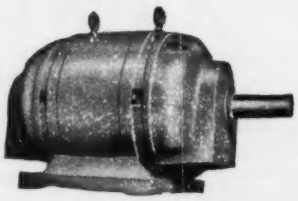
that's what you get when you Specify . . .

VALLEY

BALL BEARING MOTORS

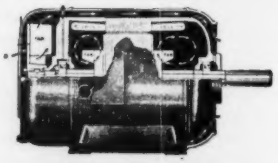
HERE'S WHY . . .

First of all they are specifically engineered to meet the exacting requirements of most power needs — regardless of type or location. Then too, they insure constant, uninterrupted service in high temperatures because they are always cool running. Having enclosed ball bearings you are assured of complete protection against harmful dust and grit. Furthermore, they can handle most power load emergencies without damage to its operating parts.



FAN COOLED

Totally enclosed VALLEY Motor Polyphase, 50 to 60 cycles, constant speed, continuous duty, squirrel cage induction, high torque, low starting current and fully ball bearing, 2 to 60 h.p.

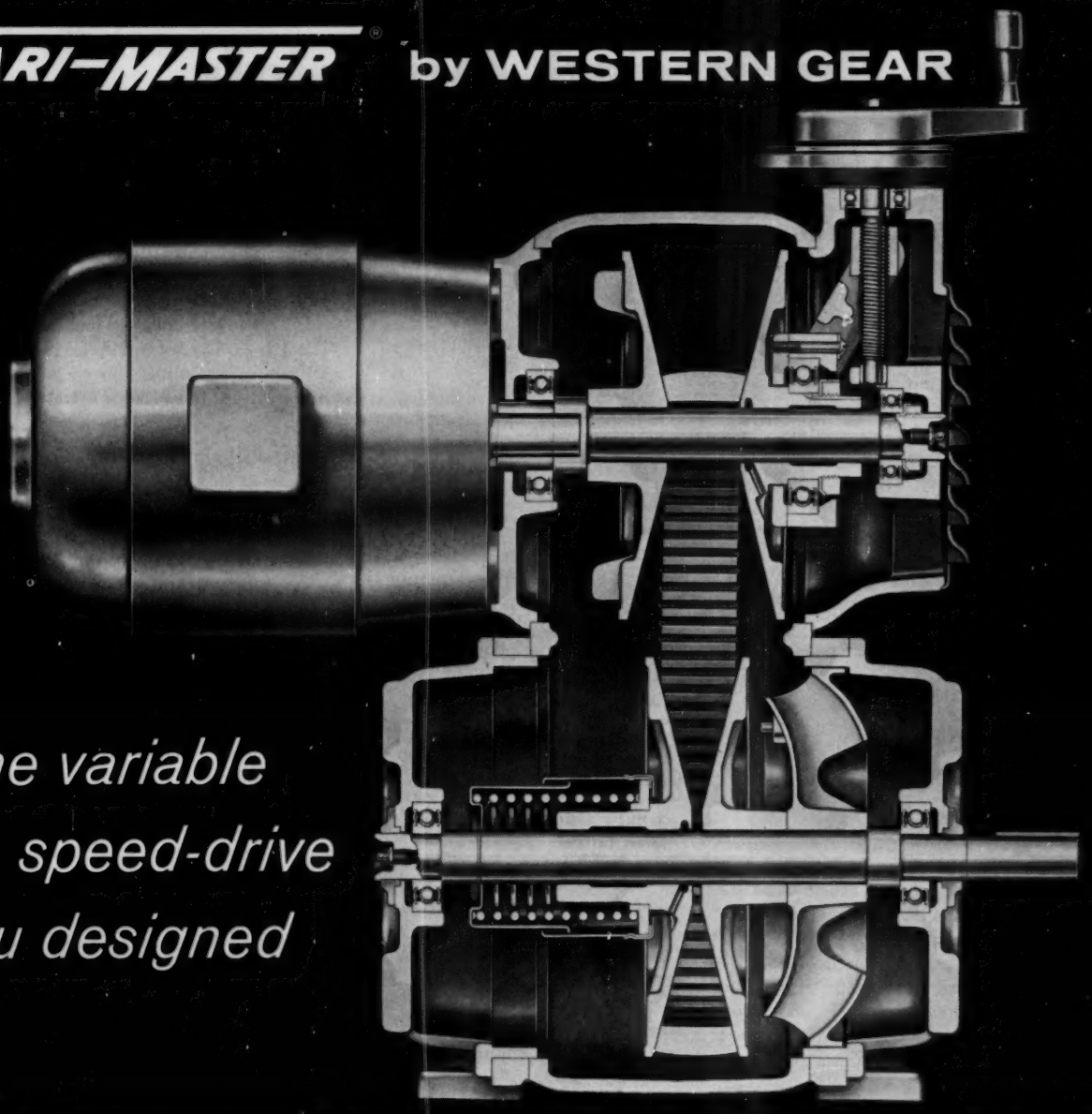


VALLEY
ELECTRIC CORPORATION
4221 FOREST PARK BLVD. • ST. LOUIS 8, MO.

Circle 337 on Page 19

YOU ASKED FOR IT!

VARI-MASTER® by WESTERN GEAR



the variable speed-drive you designed

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HOW WESTERN GEAR SERVES ALL INDUSTRY

Western Gear has designed, engineered and manufactured to customer requirements, the ultimate in variable speed drives, combining all the best features of variable speed drives, plus Western Gear's own built-in reliability and versatility. Get unequalled performance in the new Vari-Master variable speed drive. You asked for, and Vari-Master delivers ■ unmatched flexibility ■ up-to-the-minute design improvements ■ utmost compactness ■ infinitely adjustable speeds ■ unlimited versatility ■ easy motor replacement ■ 120 basic configurations ■ superb quality. *On the long run...* **QUALITY COSTS YOU LESS!** For full details, write **Western Gear Corporation,** Industrial Products Division, P.O. Box 126, Belmont, Calif., for Vari-Master Bulletin 6107F or ask your Western Gear salesman to deliver the 120-page Bulletin 6107.

Circle 338 on Page 19

OTHER TYPICAL VARI-MASTER ASSEMBLIES

WESTERN GEAR CORPORATION

WG INDUSTRIAL PRODUCTS DIVISION

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Stainless-Steel Spring Wire

has tensile strengths exceeding music spring wire

NS-355 stainless-steel spring wire with tensile strengths to 100,000 psi higher than music spring wire has potential applications which include springs for jet engines, food and beverage equipment, and chemical machinery. Higher tensile permits smaller springs for a given capability or more capability in given size springs. Guaranteed minimum tensile strength of 0.195-in. NS-355 is 290,000 psi, compared

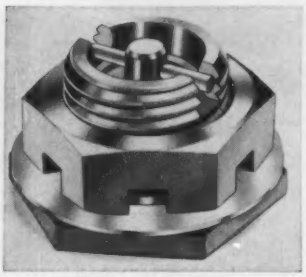
to 245,000 psi for music wire of that size. Guaranteed minimum tensile strength of 0.004-in. NS-355 is 500,000 psi, compared to 439,000 psi for music wire. Wire is suitable for compression and extension springs. It is available in diameters from 0.003 to 0.195 in. **National-Standard Co.**, Dept. RDT, Niles, Mich.

Circle 547 on Page 19

Drain Valve

drains from within 0.020 in. of tank bottom

No. 5712 light-weight drain valve can be mounted flush to any tank exterior surface. Valve drains from within 0.020 in. of the tank bottom to the absolute bottom, depending upon the method of mounting. Slight push with any blunt object the size of a lead pencil cracks the valve and permits fluid to drain.



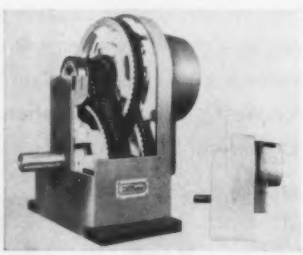
For extended or complete drainage, an upward push and slight rotation keeps the valve in full-open position. Valve is either intentionally fully open or positively closed. Designed primarily for supersonic aircraft, valve is adaptable to more conventional installations as well. **Bruning Co.**, Lincoln, Neb.

Circle 548 on Page 19

Gear-Drive Unit

compact drive uses no oil

Dry Gear Dryve speed reducer/speed increaser drive unit is suitable for conveyor systems, manufacturing and processing machinery, and other applications. There is no oil used in the unit, eliminating oil dripping. Unit is unaffected by temperature changes from −60 to +200 F. Antifriction, factory-packed bearings are used throughout. Unit can be mounted in any orientation. It is quiet because it incorporates reinforced tooth belts which provide an inherent shock absorption through their built-in



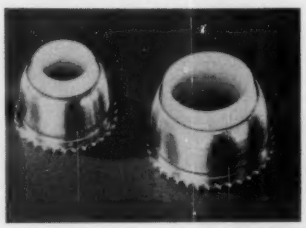
elasticity. Drives are presently available in standard ½, ¾, 1, 1½, and 2 hp, rated on output. Standard output-shaft speeds range from 16½ to 780 rpm. **Machine Control Inc.**, 310 Second Ave., N., Minneapolis 1, Minn.

Circle 549 on Page 19

Self-Aligning Bearing

for mounting in 0.040-in. or heavier sheet metal

New bearing for mounting in 0.040-in. or heavier sheet metal by a self-clinching retainer is self-aligning to 5 deg off the center line around full 360 deg. Bearing is Delrin; retainer is steel, aluminum, or stainless steel. Aluminum type can be mounted in materials of Rockwell B50 or less, steel types in B70 or less. Bearing assemblies center in a prepared hole, clinch securely, and resist torque. Assemblies can be removed by a press and a new bearing installed. Usually this can be done at least



three times without loss of holding power. Bearing is available in shaft sizes from 1/32 to ¼ in. **Spyraflo Inc.**, Drawer E, Miami 64, Fla.

Circle 550 on Page 19

Miniature Resistors

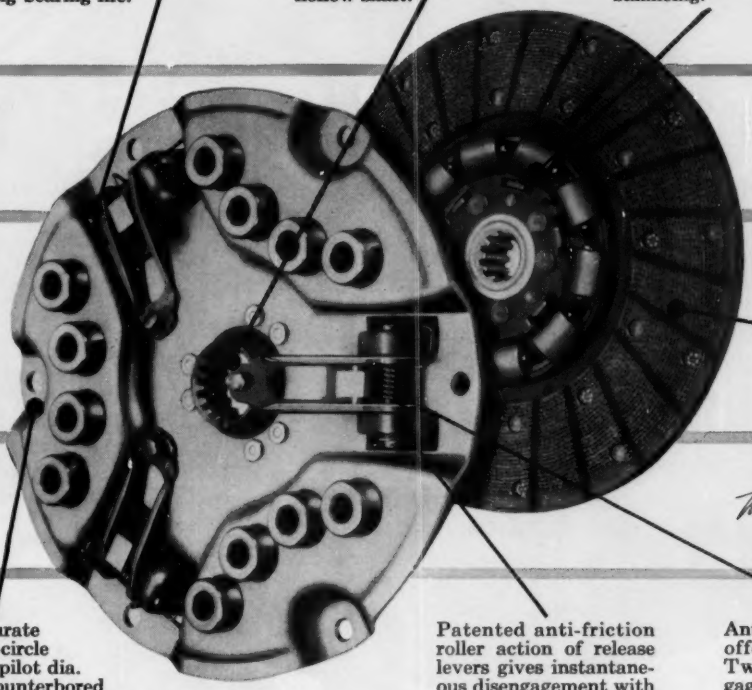
have maximum dissipation of ½ w per wafer

Microminiature resistors utilize standard RCA wafer for use in micro-module development. Dimensions of wafer are 0.31 x 0.31

Counterbalanced release levers prevent centrifugal lever "throw-out." This meets high-speed engine requirements and assures long bearing life.

Spline in cover plate provides constant-running PTO for low-cost auxiliary drives. Direct drive from flywheel through splined hollow shaft.

Vibration dampener absorbs noise and vibration from the gear-train. Clutches are vibration-free through dynamic and static balancing.



Rugged facings give longer life. Asbestos or Morlife facings offer wide torque range. Drag-machine inspection assures uniform thickness.

See us at the Milwaukee S.A.E. Show Sept. 11 to 14

Accurate bolt-circle and pilot dia. fit counterbored flywheels perfectly. Minimum-inertia design prevents gear clashing and delayed shifting.

Patented anti-friction roller action of release levers gives instantaneous disengagement with minimum pedal pressure and longer lever life.

Anti-rattle lever springs offer quiet operation. Twelve powerful engagement springs, properly spaced over facing area, assure maximum driving contact.

NEW Dual-Drive FA Clutches meet your high-speed engine needs

The new Rockford FA Spring-Loaded Clutches are specially designed for your high-speed engines. Counterbalanced release levers permit high-speed operation without increasing pressure required to release. High-strength, low-inertia design gives high-speed drives without gear clashing or delayed shifting. Patented anti-friction roller action of release levers allow instantaneous disengagement with lower pedal pressure and longer lever life. FA dual-drive clutches provide a built-in live power take-off. This low-cost auxiliary drive runs constantly from flywheel through splined hollow shaft. Through a choice of springs and facings, FA Clutches are available in a wide range of torque capacities. Write today for complete information.

International Harvester 660 Tractor equipped with Rockford FA Spring-Loaded Clutch.

ROCKFORD CLUTCH

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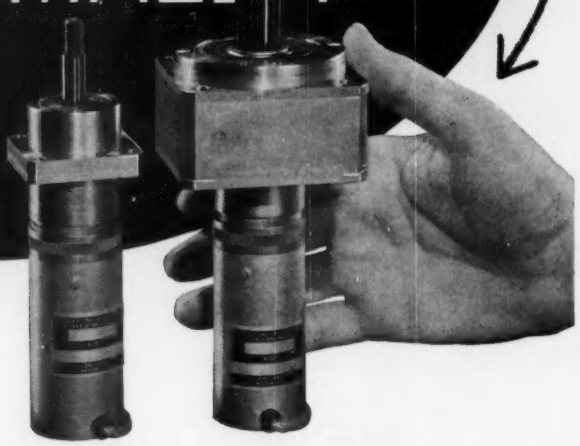
Export Sales Borg-Warner International • 36 So. Wabash, Chicago, Ill.

ROCKFORD BW CLUTCH

DIVISION OF BORG-WARNER

1000 INCH-LBS. TORQUE THAT SMALL ?



You can use these new Globe planetary gearmotors to replace units 5 to 10 times as large and heavy. They slash pounds of dead weight from your design—give you up to 500 inch-pounds continuous duty or 1000 inch-pounds intermittent duty torque. Here's enough brawn to handle aircraft, missile and other high-quality, high-reliability jobs. Smaller gearbox shown above gives 200 in.-lbs. intermittent, 100 in.-lbs. continuous duty.

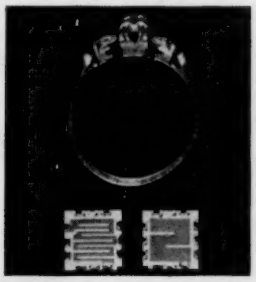
Globe's brand new planetary gearing system provides 22 ratios from 1.87:1 to 5211:1. Stage efficiency of 90% or better has been achieved by using heavy duty precision ball bearings on every gear and on the output shaft. Heat treated gears and hardened output shaft withstand enormous turning and bending moments. Type BD and BL gearmotors fit your application exactly, using 21 standard armature windings for 4 to 115 v.d.c. power—custom design for your application can include speed governors, brakes, and clutches. 1¾" flange gearmotor typically weighs 1½ lb.; 3" flange high-torque gearmotor weighs 4¾ lb. typ.

Let Globe engineers review your application early in the design stage. Prototypes furnished promptly. Write for Bulletin BPG. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. Phone BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. CLUTCHES. BLOWERS. FANS. MOTORIZED. DEVICES

GLOBE



x 0.10 in. Wafer has 12 interconnecting notches, three to each side. Electrical specifications are: Resistance range from 100 to 100,000 ohms, tolerance ± 1 per cent, temperature coefficient of 100 PPM per deg C, and a maximum dissipation of ½ w per wafer. As many as four resistive elements can be placed on a single wafer. **Dale Electronics Inc.**, Columbus, Neb.

Circle 551 on Page 19

Laminated Shims

of titanium have high tensile strength

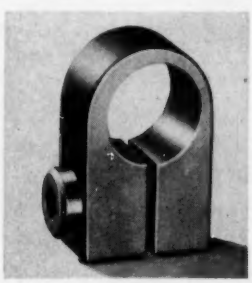
Multiple 0.003 in. layers of titanium are now plastic-bonded to each other and, if desired, to a single, thicker sheet of titanium, to make custom-built laminated shims to specifications. Shims of this material fulfill weight-saving and high tensile-strength requirements for spacecraft and missile-component assemblies, and feature peelability advantages as shims made of other metals. **Laminated Shim Co. Inc.**, Glenbrook, Conn.

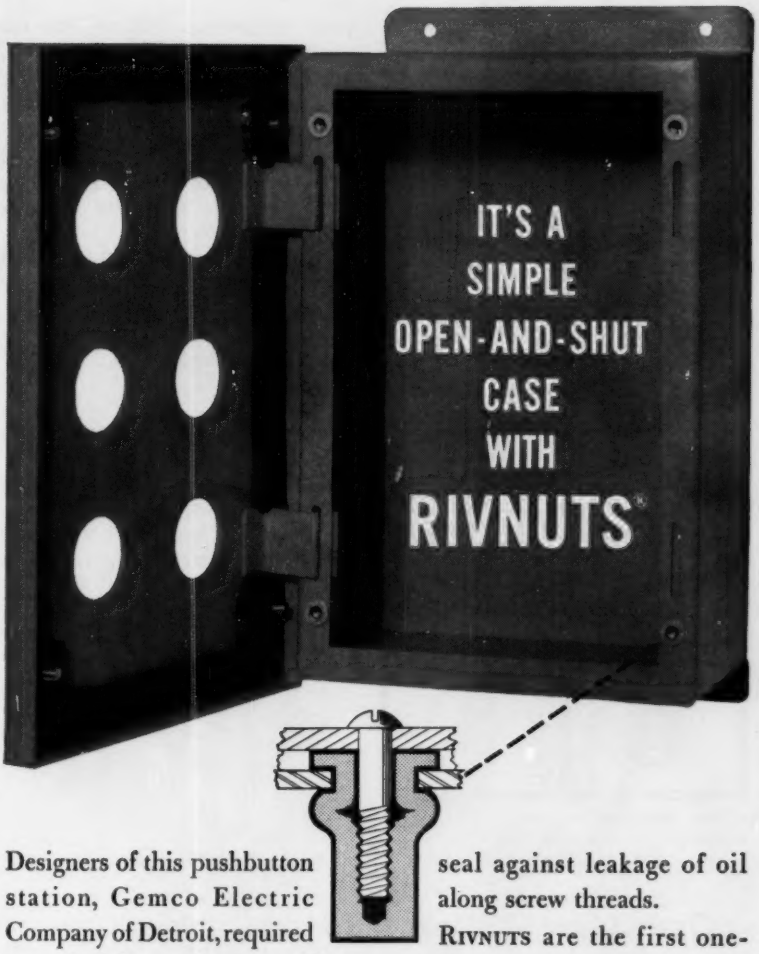
Circle 552 on Page 19

Subminiature Gear Clamps

in new ⅛-in. bore size

Subminiature, balanced-type gear clamps with new ⅛-in. bore size lock in place subminiature components in computers, gear trains, and





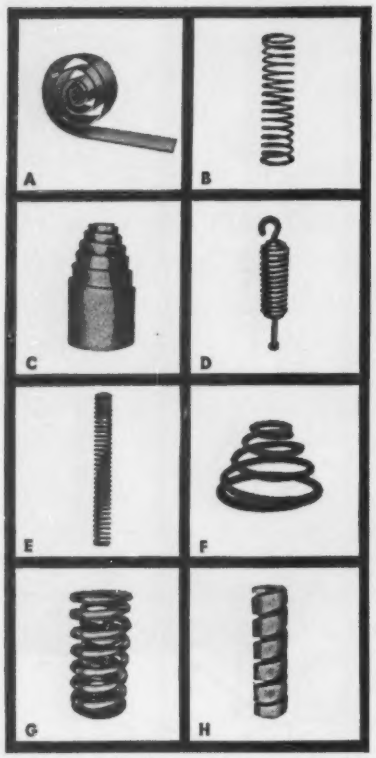
Designers of this pushbutton station, Gemco Electric Company of Detroit, required an oil-tight enclosure with a cover that could be attached or removed as simply as possible. The usual solution would be clamps and brackets. Instead, RIVNUTS were installed in the frame so that the cover could be fastened to them with ordinary screws. With RIVNUTS as sturdy nutplates, time and cost of assembly is greatly reduced. There's no need for drilling and tapping blind holes. And RIVNUTS with closed ends effectively seal against leakage of oil along screw threads.

RIVNUTS are the first one-piece blind rivets with internal threads. They help solve many fastening problems faster—better, and at reduced cost. New data book describes principle, typical applications, lists sizes and tool data. For a free copy write Department MD-8, *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*

B.F.Goodrich
RIVNUTS

Circle 341 on Page 19

Can you identify these springs?



A. flat B. helical C. volute D. extension E. helical F. cone G. helical, triple-coil H. rectangular section

Over One Million ALCO SPRING DESIGNS

ALCO's complete line of "performance-rated" springs ranges from small springs for light work to heavy-duty triple-coil springs for heavy, sustained work.

In over 80 years, ALCO engineers have produced more than one million spring designs to serve almost every conceivable application.

For your next spring job, contact your nearest ALCO sales office. To obtain brochure, ALCO *Springs for Industry*, write to ALCO Products, Inc., Dept. 160, Schenectady, N. Y.

ALCO

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NEW YORK
SALES OFFICES IN PRINCIPAL CITIES

Circle 342 on Page 19

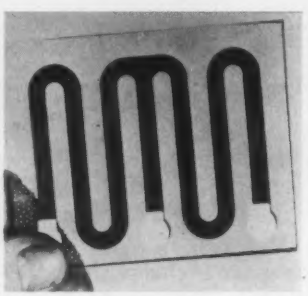
other instruments. Other sizes are available in the same configuration. Also available from stock are over 150 different types of instrument clamps for electromechanical equipment, in shaft sizes of 1/8, 1/4, 3/16, and 5/16 in. **Siamco Div., Tech-Ohm Electronics Inc.**, 36-11 33rd St., Long Island City 1, N. Y.

Circle 553 on Page 19

Compact Heating Element

produces temperatures over 300 C

Compact glass heating element is available for use as a low-temperature warmer or in spot-heating applications. Unit consists of borosilicate glass panel, selectively coated with a metallic film. Film is



applied to form an electrically conductive path which permits maximum amount of heat to be generated from a minimally sized panel. Unit can produce temperatures of over 300 C with glass sizes from 1 to 27 3/8 in. square and from 3/32 to 1/4 in. thick. Resistance per square of coating can be varied from 6 to 100 ohms. Maximum dissipation is 10 per square of coated area. Infrared reflecting qualities of the metallic film permit the unit to serve as a spot shield for delicate materials. **Corning Glass Works**, Corning, N. Y.

Circle 554 on Page 19

Two-Part Epoxy Resin

for bonding metal to metal has high impact resistance

Miracle NP 711 two-part thermosetting epoxy resin is a strong, flexible adhesive highly resistant to impact. Curing schedule varies, depending on nature of materials being bonded, thickness of bond line,

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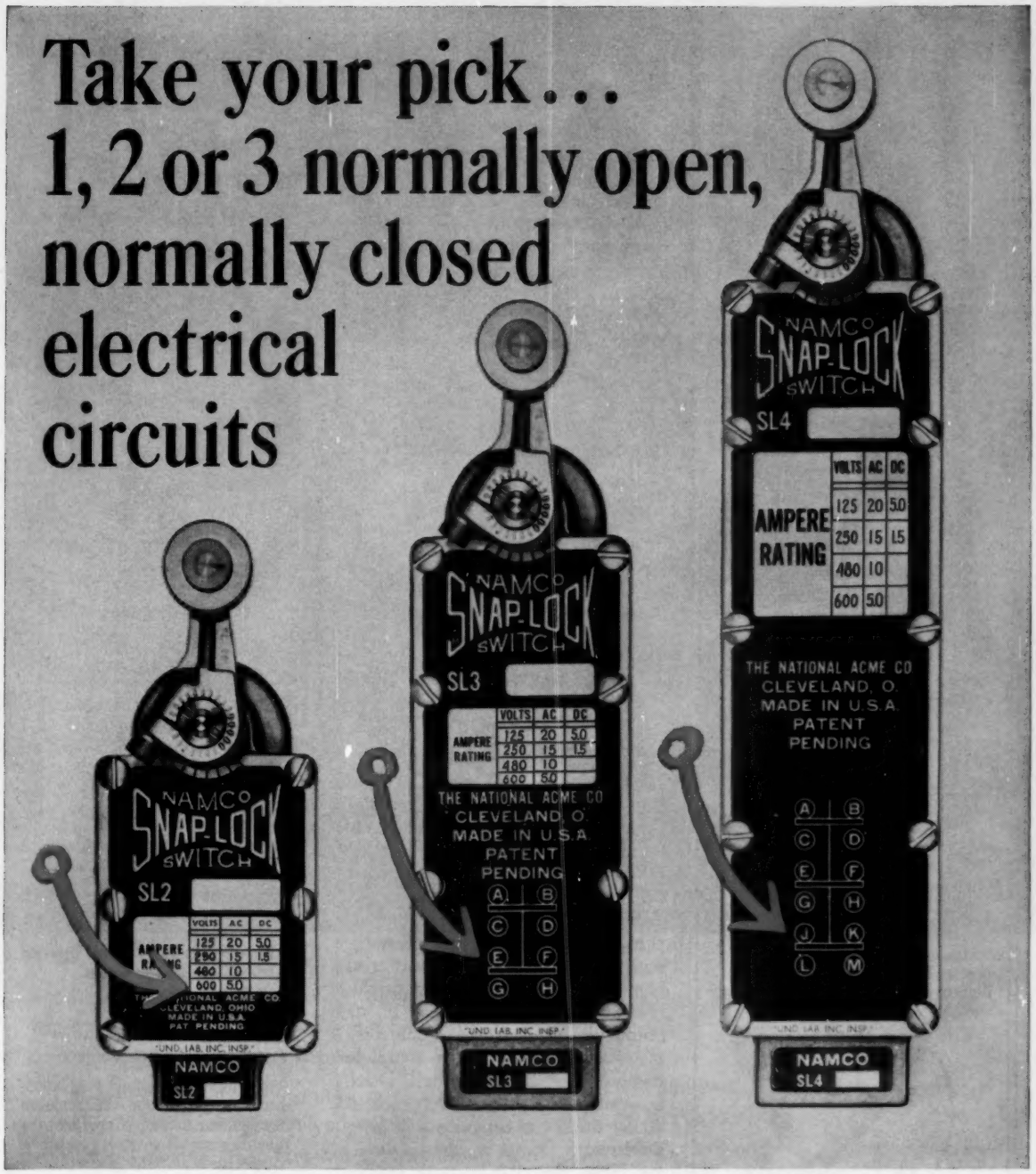
Circle 343 on Page 19

Take your pick... 1, 2 or 3 normally open, normally closed electrical circuits



What does your limit switching application call for . . . one, two or three normally open, normally closed electrical circuits? Whatever it is, one of these National Acme SL "Machine Life" Limit Switches . . . the SL2, the SL3 or the SL4 . . . will meet your precise requirement. And, every SL offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (10½ lbs. at 1½" radius). Also available . . . the SLS 2, 3 or 4 featuring "hi-shock" sliding contacts; particularly suitable for drop forge, punch press and other heavy equipment application. Call, write or wire for complete information.

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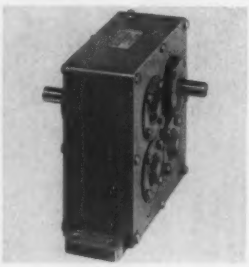
Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

and temperature conditions. Generally, assembly can be moved about in 1½ to 2 hr, and complete cure occurs in 24 to 48 hr at room temperature. Addition of heat shortens curing time. Working or pot life ranges up to 1½ hr, depending on mass of material that is mixed. Minimum working life does not fall below 45 min. Temperature range is −40 to 250 F. Product is nonflammable and practically nontoxic. **Miracle Adhesives Corp.**, Bellmore, L. I., N. Y.

Circle 555 on Page 19

Intermittent-Motion Drive

is available in 40 and 140-deg dwell units



New intermittent-motion drive, designed to provide a smooth acceleration-deceleration motion, is called Dwel-Drive. Unit can be attached easily to packaging equipment, indexing tables, metalworking machines, punch presses, and pressure-sensitive tape machinery. It also eliminates shock loads on single-revolution clutches because of its output shaft which makes one complete revolution for each complete revolution of the input shaft. Drive is available in two models, one a 40 deg dwell and the other a 140-deg dwell; both have a maximum working torque of 50 lb-ft. Both models are square shaped, measuring 9¾ in. square. **Remmele Engineering Inc.**, 515 University Ave., St. Paul, Minn.

Circle 556 on Page 19

Constant-Force Springs

in high-force and light-duty units

Twenty-one Neg'ator constant-force extension springs are now available from stock. Series H springs are designed for high force and have a

RIGHT... on the spot for spot heating

Vulcan Cartridge Heaters are *right* on the spot . . . for spot heating . . . with a complete quality controlled line which includes standard; high watt density; and ceramic elements.

VULCAN STANDARD CARTRIDGE HEATERS

Vulcan Cartridge Heaters are available in a wide choice of lengths, diameters, sheath materials, wattage and voltage ratings.

VULCAN "THUNDERBOLT"

The "Thunderbolt" delivers as much heat as a conventional cartridge *5 times its size.* You get ratings as high as 200 watts (or even higher) *per square inch* of radiating surface.

VULCAN CERAMIC HEATERS

These are ideal for volume production in spot applications which require a cartridge type unit where high watt density and ruggedness are not prime requisites.

Write for Bulletin *VG*-300A.

VULCAN

Versatility in Electric Heating

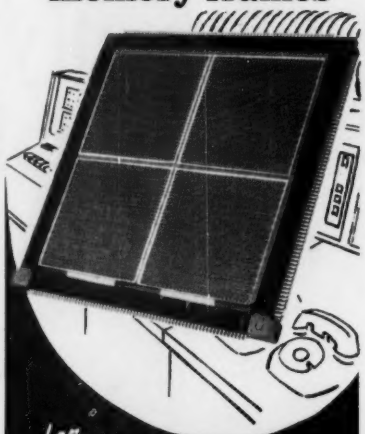
VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 345 on Page 19

example...

FIBERITE

at work in computer memory frames



for IBM Corporation (Poughkeepsie)

Memory-core frames are a vital part of IBM's fabulous computers.

These frames hold and protect the tiny "memory units" which store information for processing.

IBM Poughkeepsie, working with Fiberite Corporation, specified a reinforced plastic frame material with these characteristics:

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- Good molding characteristics
- Automatically preformable

With Fiberite compound F.M. 4005, the exact formulation was achieved through the intense cooperation of Fiberite research engineers and their counterparts at IBM. Results have been called "outstanding."

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Circle 346 on Page 19

A cylinder doesn't think but you do—and when you turn your thoughts to how a machine can perform, a lot of things can happen.

The cylinder responds instantly when activated, and does exactly what you tell it to do with pre-set adjustments. You can synchronize it with the motion of related machines or attach it to a moving machine.

It will produce almost any kind of motion—and do so *without the use of complex mechanical contrivances!*

For more information about Logan products, just fill in the coupon below.

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Circle 347 on Page 19

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___100-2 MILL-TYPE AIR CYLS.
___100-3 AIR-DRAULIC CYLS.
___100-4 AIR VALVES
___100-5 LOGANSQUARE CYLS.
___100-6 ULTRAMATION CYLS.
___100-7 SUB-PLATE AIR VALVE
___300-1 CHUCKS
___300-2 PRESSES
___200-1 HYD. POWER UNITS
___200-2 ROTOCAST HYD. CYLS.
___200-3 750 SERIES HYD. CYLS.
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Circle 348 on Page 19

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★ up to 6" diameter
★ up to 24" long
★ "V" Threads
★ Acme Threads
★ Worm Threads
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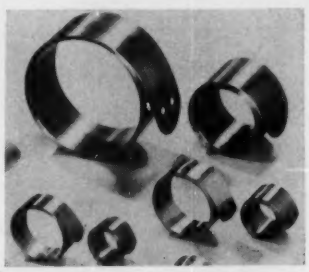
Circle 349 on Page 19



minimum life of 2500 cycles of operation. Series L light-duty springs have a fatigue rating of 20,000 cycles minimum. Spring load varies from 0.23 lb for the smallest light-duty unit to over 40 lb for the largest high-force spring. Useful extension of the springs varies from 12 to 42 in. Force delivered by each spring remains constant over its entire deflection range, exhibiting no spring rate or gradient. **Hunter Spring Co. Div., American Machine & Metals Inc.**, 1 Spring Ave., Lansdale, Pa.

Circle 557 on Page 19

Self-Adhesive Material

has service temperature range of −20 to +250 F

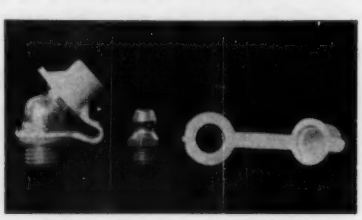
Decorative self-adhesive material, available in 33 standard colors and 12 embossing patterns of simulated leather and linen-prints, is available for trim and covering of all kinds. Dec-a-Tex is applied to any clean, smooth, dry surface by removing protective backing paper and pressing into place. Service temperature range is −20 to +250 F. Material resists greases and oils, creeping, fading, shrinkage and abrasion. **Fasson Products**, 250 Chester St., Painesville, Ohio.

Circle 558 on Page 19

Grease-Fitting Cover

withstands extreme operating conditions

One-piece, flexible-plastic, grease-fitting cover consists of retainer ring

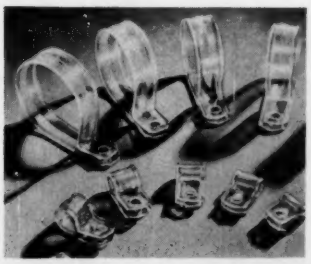


that stretches over hex surface of grease fitting while in place on equipment; strap hinge that holds cover onto fitting base during greasing operation; and cap that snaps over top of fitting to seal out contaminants. Cover is polyurethane plastic which withstands extreme operating conditions and is flexible to fit all types of hydraulic grease fittings. It is available in a variety of bright colors and can be used for color coding type of lubricant, frequency of lubrication, or to make fittings easier to locate on equipment. **Lubrication Specialty Co.**, 6025 Denton Drive, Dallas 35, Tex.

Circle 559 on Page 19

Butyrate Cable Clamps

are weather-resistant for outdoor use



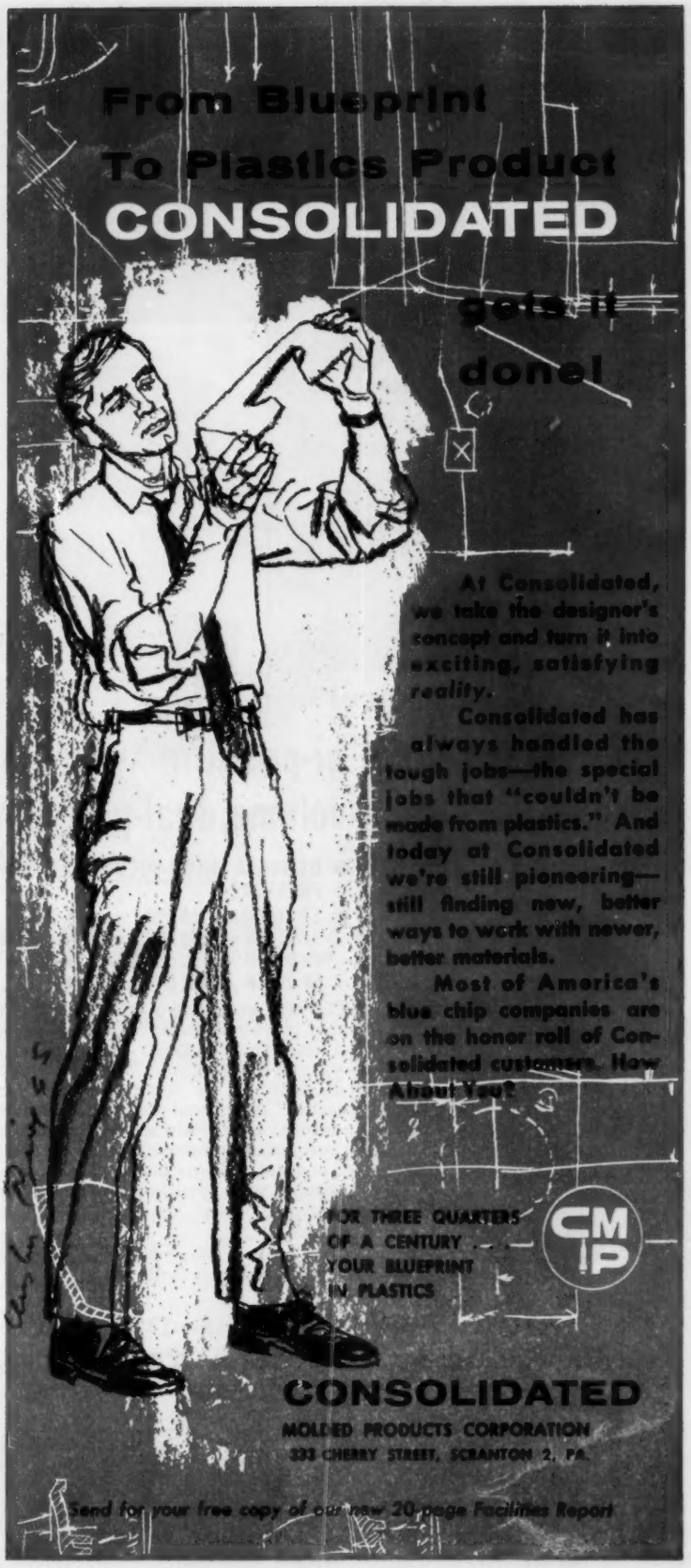
Type 6B ½-in. wide clamps provide cable support and long life with continuous exposure to sunlight, moisture, industrial atmospheres, and temperature extremes. Butyrate formula used in the clamps is approved under Military Specification L-P-349a, Type III—Class MH. Clamps are available from stock in clear color, for wire sizes from ⅛ to 1½ in. **Weckesser Co. Inc.**, Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill.

Circle 560 on Page 19

Pulsation Dampener

for use with pressures to 10,000 psi

Available in stainless-steel or rolled-brass construction, pulsation dampeners for pressure gages are for use on pumps, compressors, and other pulsation-producing air, gas, or liquid-handling equipment within a limit of 10,000 psi operating pressure. Dampeners guard against excessive wear or destruction of gage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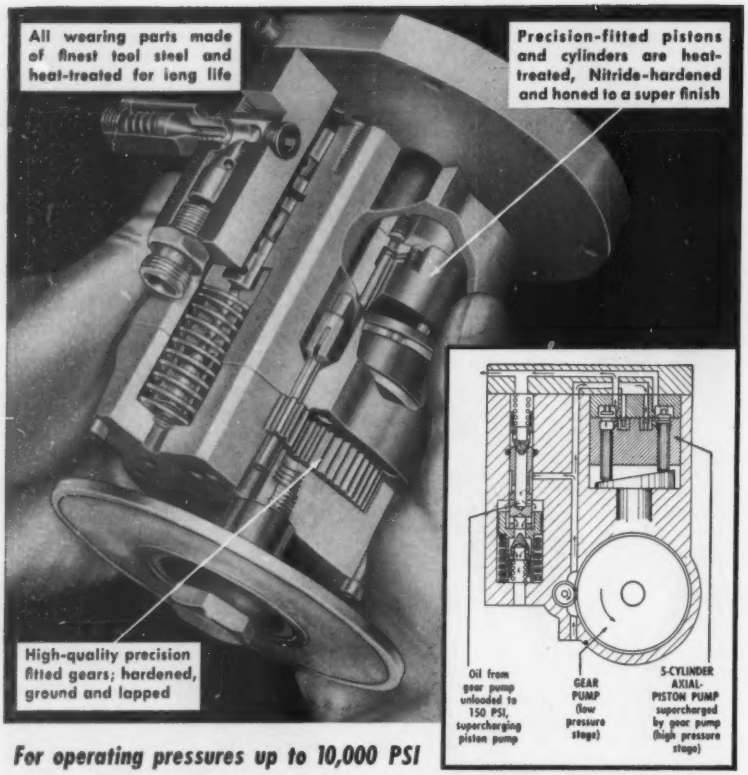
gets it
done!
At Consolidated, we take the designer's concept and turn it into exciting, satisfying reality.
Consolidated has always handled the tough jobs—the special jobs that "couldn't be made from plastics." And today at Consolidated we're still pioneering—still finding new, better ways to work with newer, better materials.
Most of America's blue chip companies are on the honor roll of Consolidated customers. How About You?
FOR THREE QUARTERS OF A CENTURY . . . YOUR BLUEPRINT IN PLASTICS
CMP
CONSOLIDATED
MOLDED PRODUCTS CORPORATION
333 CHERRY STREET, SCRANTON 2, PA.
Send for your free copy of our new 20-page Facilities Report

Circle 350 on Page 19


All wearing parts made of finest tool steel and heat-treated for long life
Precision-fitted pistons and cylinders are heat-treated, Nitride-hardened and honed to a super finish
High-quality precision fitted gears; hardened, ground and lapped
Oil from gear pump unloaded to 150 PSI, supercharging piston pump
GEAR PUMP (low pressure stage)
5-CYLINDER AXIAL-PISTON PUMP supercharged by gear pump (high pressure stage)

For operating pressures up to 10,000 PSI

New, unique 2-stage hi-pressure hydraulic pumping unit—dual-volume, dual-pressure

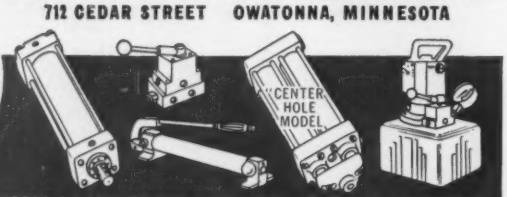
- **DELIVERS HIGH-VOLUME AT LOW PRESSURE**
- **2.6 GPM @ 100 PSI**
  1.75 GPM @ 500 PSI
  80 CU. IN./MIN. @ 1,000 PSI
  50 CU. IN./MIN. @ 10,000 PSI

The new and modern OTC "Vanguard" hi-lo hydraulic power package is a precision-built, high-quality unit meticulously crafted for dependable performance and long life. To best utilize the "Vanguard's" exceptional performance, a wide range of accessories are available: your choice of several motors, gasoline engine, 2 and 4-way lever-control valves, 2-way solenoid valve, pressure switch, pressure regulating valve, manifold, reservoirs, gauges, etc.

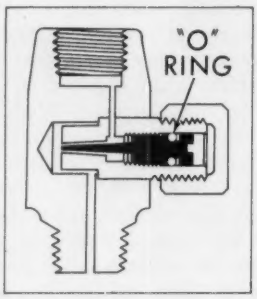
For detailed information on this advanced, new unit, write:

PRECISION HYDRAULICS DIVISION
OWATONNA TOOL CO.
712 CEDAR STREET OWATONNA, MINNESOTA

RESEARCH · ENGINEERING · DEVELOPMENT
OTC



DESIGNERS AND MANUFACTURERS OF QUALITY HIGH PRESSURE HYDRAULIC COMPONENTS



mechanisms, and maintain calibration accuracy. They utilize a variable orifice which permits full pressure measurement but prevents surge or shocks by throttling abrupt pressure changes of large or small amplitude. Orifice can be adjusted externally without line or gage disconnection. Sizes are ¼ and ½ in. **Kunkle Valve Co.**, Ft. Wayne, Ind.

Circle 561 on Page 19

Plastic Fasteners

are available in small sizes

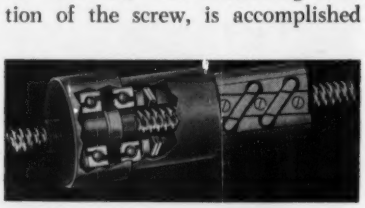
Plastic fasteners (machine screws, nuts, and set screws) are available in new sizes which include 0-80 x 3/32 in. through ⅜ in. and 1-72 x ⅛ in. through ½ in. Machine screws contain standard slotted heads. Set screws are slotted headless type. Only restriction in nut sizes is a 1/16-in. minimum thickness. Stock materials is Zytel 101; other materials such as Lexan, PVC, and Lucite are also available. **Anti-Corrosive Metal Products Co. Inc.**, P. O. Box 1894, Albany 1, N. Y.

Circle 562 on Page 19

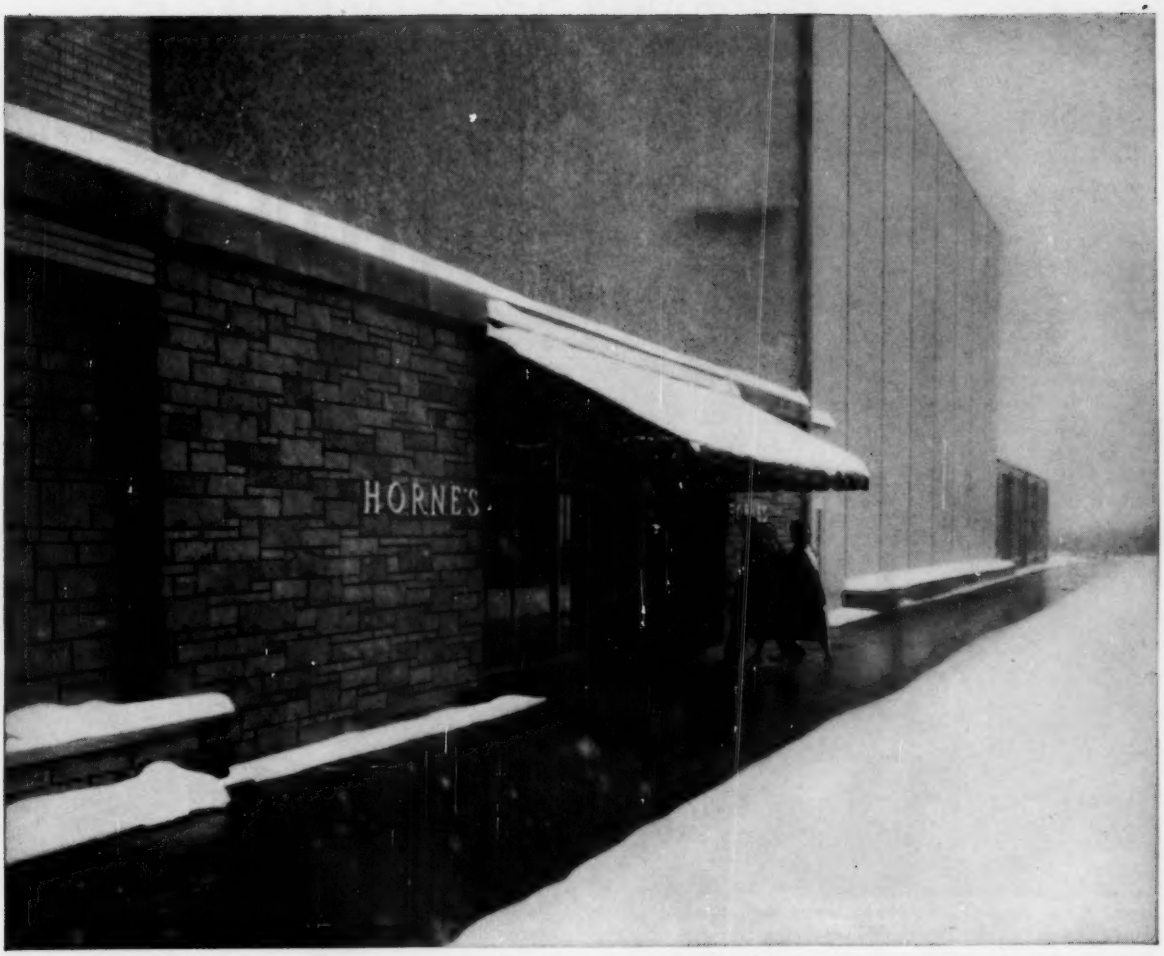
Ball-Bearing Screw

permits freewheeling of the ball nut

On a new line of ball-bearing screw assemblies, travel of the ball nut is halted at any position along its stroke where the load reaches a preset amount. Freewheeling of the ball nut, with continuing rotation of the screw, is accomplished



Circle 351 on Page 19



This sidewalk is wired for snow

Nickel alloy electric heating cables in the concrete melt snow as fast as it falls!

No shoveling, no salting, no customer accidents on slippery sidewalks at *this* suburban branch of a Pittsburgh department store. Electric heating cables keep the sidewalks clear of snow and ice during even the worst winter weather.

Saves maintenance costs. In addition to taking the bother out of blizzards, the system eliminates the cost of conventional sidewalk clearance. And further savings are realized because the heating cables – made of 80% Nickel – require no maintenance.

High Nickel alloy cables were used because of Nickel's superior resistance to corrosion, fatigue and extreme temperatures. These Nickel alloy cables will withstand years of repeated heating and cooling, and seasonal expansion and contraction of the concrete.

Just one example of Nickel's versatility. Electric heating cables–also used to melt snow and ice from roofs and driveways – is another example of how Nickel helps make possible new products and processes, and improves existing ones. In most any application, Nickel's wide range of important properties . . . corrosion resistance, strength, long life and beauty, to name just a few . . . offers proven advantages.

If your business is metals, or if you use metals in your business, call on Inco for the latest information about how Nickel and its alloys can help you.

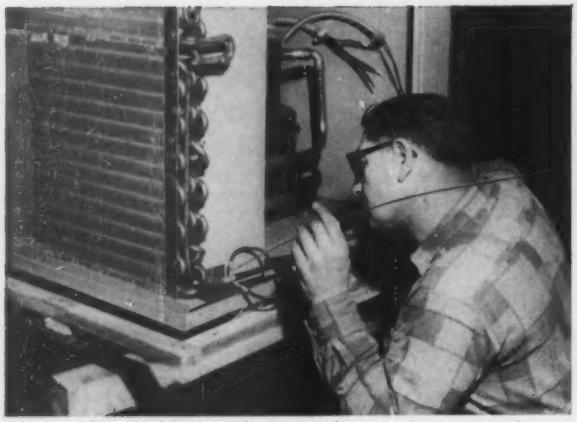
Imbedded near the concrete surface, electric heating cables of 80% Nickel keep the sidewalks clear of snow and ice. Cables made by Edwin L. Wiegand Company, Pittsburgh.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

HOW TO MAKE 4,999 JOINTS WITHOUT FAIL



Here, with a double tipped oxyacetylene torch, operator brazes condenser coil joints. This condenser-compressor assembly contains 30 hook-up joints, not counting return bends.

The unit evaporator, located inside the house, contains 36 hand-brazed SIL-FOS 5 joints.

International Heater Does it With HANDY & HARMAN SIL-FOS 5

Production statistics of this manufacturer of heating and air-conditioning equipment show that perhaps one in five thousand hand-brazed joints may need touching up. This is a micrometer measurement away from absolute perfection.

One of the Utica, New York, company's products is a home air conditioner that utilizes the existing duct work of the structure's hot-air furnace. Its novelty lies in the fact that the unit's compressor and condenser are located outside the house for noise-free coolness inside the home.

The unit's evaporator is installed on top of the furnace for simple tie-in to the plant's ducting for hot-weather operation.

Shown here in production is International's Model 5-5B of 5 ton capacity.

This "joint in quantity" record is being duplicated by SIL-FOS 5 silver alloy brazing in the manufacture of heating, air-conditioning and refrigeration equipment everywhere. Its strength, air- and leak-tightness and ease of application are some of the reasons that make Handy & Harman SIL-FOS 5 brazing one of the *surest* metal joiners in existence. We'd like you to know more about SIL-FOS 5 and the job it can do for you in joining copper and copper alloys in any shape, size and complexity. Our Bulletin 20 deals with this in a complete and informative manner. A request to Handy & Harman, 850 Third Avenue, New York 22, N.Y. will bring you your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

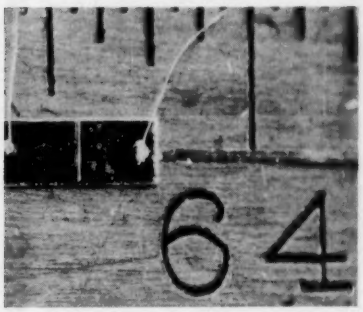
General Offices: 850 Third Avenue, New York 22, N.Y.

by providing two angular-contact ball bearings and Belleville washers in a split housing attached to the nut. Power for driving is applied to threaded end of housing. Desired amount of preloading is applied to angular-contact bearings by screwing housing sections together or apart. Torque is transmitted through preload unit to ball nut; when load exceeds preset amount, housing and nut freewheel on the stud and screw. Assemblies are available in a full range of sizes. **Saginaw Steering Gear Div., General Motors Corp.**, Saginaw, Mich.

Circle 563 on Page 19

Micro-Photo-Sensor

provides sensitive light-spot displacement measurements



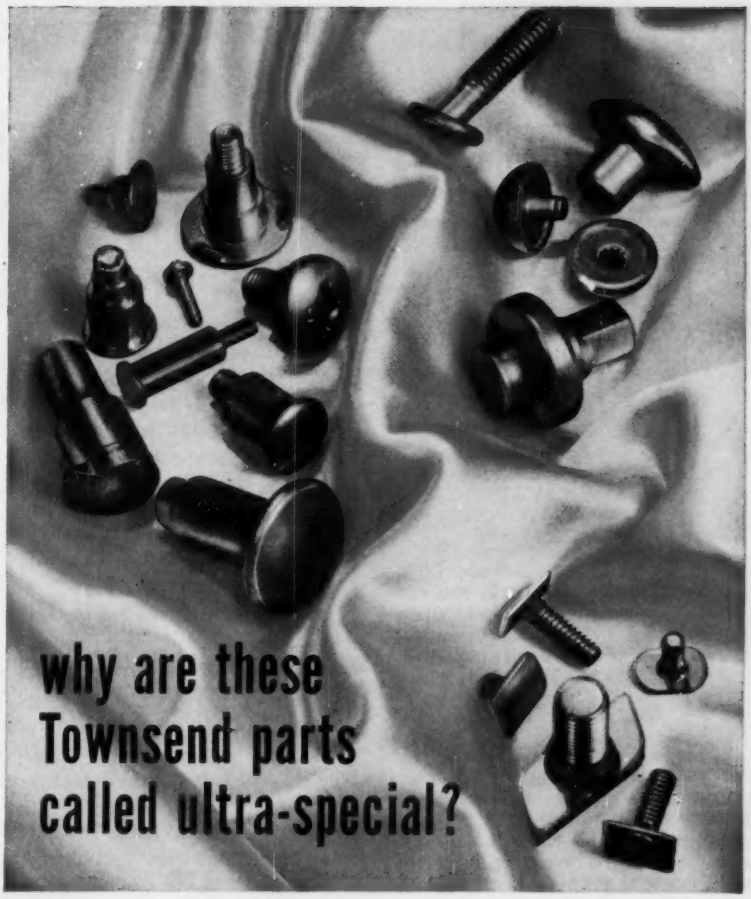
MPS 100 micro-photo-sensor is suited for applications prohibiting mechanical loading and where a controlled intensity light spot may be employed. It consists of an integral pair of similar silicon photo diodes accurately separated. Output is a differential EMF which measures the difference in light power incident upon its active cell surfaces. Typical characteristics obtained with a 2800 K tungsten source include light sensitivity of 250 mv at 50 mw per sq cm, light displacement sensitivity of 35 mv per mw per 0.001-in. open-circuit voltage with 0.020-in. diam light spot. **Micro Systems Inc.**, 319 Agostino Rd., San Gabriel, Calif.

Circle 564 on Page 19

Spherical Plug Valve

has rapid, quarter-turn opening

Spherical plug valve has a straight-through flow equal to Schedule 40



We call the metal parts shown here Ultra-Special because they are the result of completely new cold-forming and finishing techniques. They are typical examples of how users are reducing costs by taking advantage of the strength, improved quality, close dimensions and economy of mass-producing parts by cold-forming.

In the past, the limitations of the cold-forming process forced manufacturers to accept parts which were made by other, more costly methods. Now, through extensive research and development work Townsend is cold-forming Ultra-Special items with intricate shapes and critical dimensions held to tolerances as close as .001 inch. They may be made by combining cold-heading processes with impact extrusions, special heat-treatment and coatings, to name but one of the new techniques.

The use of Townsend Ultra-Special items in your product assembly could provide the means to make better products at lower costs. Investigate by asking a Townsend field engineer to call. Write Townsend Company, Engineered Fasteners Division, P. O. Box 71-E, Ellwood City, Pa.

Townsend Company

ESTABLISHED 1816

Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

In Canada: Parmenter-Bulloch Manufacturing Co., Limited, Gananoque, Ontario

Circle 353 on Page 19

HOW TO SAVE MONEY BY RIVETING

I **Design** for rivets. Use their adaptability not only for assembly, but for electrical contacts, pivots, inserts in molded materials, fastening a number of parts in one operation, joining metallic and nonmetallic parts together or to each other.

II Plan on **high speed assembly.** Riveting is a high speed operation, and even manually operated machines include automatic hoppers. The uniform quality and strength of Milford semi-tubular, tubular, split or compression rivets permits the use of high speed production equipment by unskilled operators.

III Count on a **positive** joint. A riveted joint can be visually inspected, an advantage not to be overlooked when compared to many other methods of fastening.

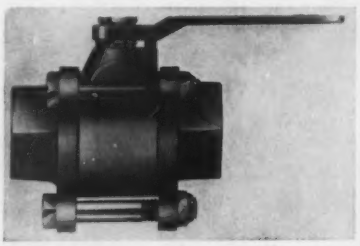
IV **Use** Milford's "five plant" facilities. Each Milford plant is strategically located to serve the important industrial areas of the U.S. **Order** and **get** Milford Products **when** and **where** you need them.

Have **uninterrupted production** with Milford rivet-setting machines. Used singly, or in economical "multiples", where you set more than one rivet with no increase in labor or handling costs, Milford riveters, setting Milford rivets, are the surest way to lowest in-place assembly cost.

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

Circle 354 on Page 19



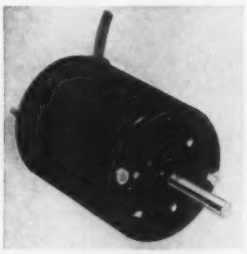
pipe. It is opened or closed with a quarter turn, and has an operating handle which can be revolved to a more convenient position. Valve is nonlubricated, has self-wiping action to eliminate scoring and galling. Sizes in bronze from 1/8 to 2 in. in screwed male or female ends and in sweat ends are available. **Pittsburgh Brass Mfg. Co.**, 3155 Penn Ave., Pittsburgh, Pa.

Circle 565 on Page 19

Electric Motor

has load speed from 2500 to 20,000 rpm

New B motor is supplied in horsepower ratings of 1/40 to 1/3; load speed varies from 2500 to 20,000 rpm, depending on requirements. Voltage ratings range from 4 to 220 v, ac, dc or ac/dc. Diameter is 3 in.; length (excluding shaft) varies from 3 to 4¼ in., depending on hp required. Motor is available with either steel or die-cast case. It is recommended for a variety of ap-



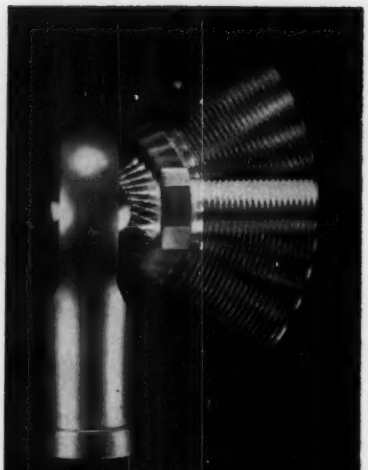
plications including pumps, rug cleaners, toy automobiles, electric brooms, vacuum cleaners, and power tools. **Heinze Electric Co.**, 685 Lawrence St., Lowell, Mass.

Circle 566 on Page 19

Selenium Rectifiers

have cells of 0.010-in. aluminum stock

Miniature Vac-U-Sel thin-cell selenium rectifiers in paper-base, phe-



WHAT MAKES *Alinabal* ROD ENDS BETTER?

One reason for the superior performance of Alinabal Rod Ends and Spherical Bearings is the precise control of the relationship of the spherical race to the ball.

Each Alinabal unit has a precision ground, through hardened steel race. Precise control of the race radius enhances low friction operation and prevents "end-loading" effects. This spherically ground race is manufactured for assembly around the ball, and is *not* a set of relatively soft, pressed inserts, nor is it a swaged housing. Moreover, loading slots are not used in the Alinabal construction method. Thus, the ball is positively and permanently retained under misaligning conditions.

Alinabal is the registered trade name for rod ends and spherical bearings manufactured under U.S. Patent 2,781,238.

A complete line — standard male and female rod ends — stud type rod ends — standard spherical bearings and rod linkages — sizes range from 3/16" to 4" bore.

SEND FOR COMPLETE CATALOG

split ballbearing

SBB DIVISION OF MPB INCORPORATED

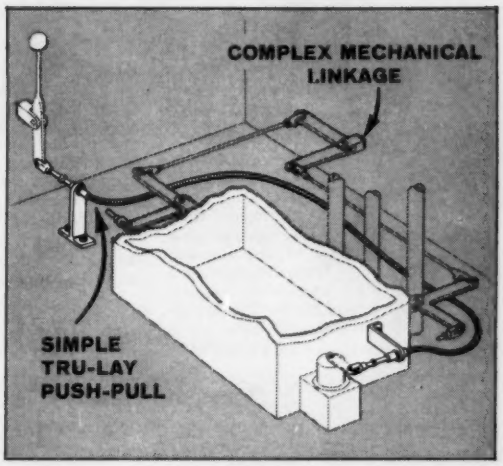
LEBANON, NEW HAMPSHIRE

Circle 355 on Page 19

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE

Dependable Economical Easy-to-Use REMOTE CONTROL

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances —up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They're factory-lubricated for life, unaffected by temperature extremes. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



CABLE SIZES AVAILABLE

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65–125
3/16"	5	115–175
1/4"	6	300–600
5/16"	8	700–1,000

Operating Heads to Fit Your Design
for loads up to 125 lbs.

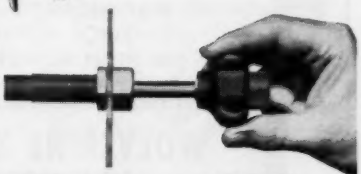
Heavy Duty • For rugged duty, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Smooth, accurate, dependable performance at low cost. Your choice of several types of knobs.

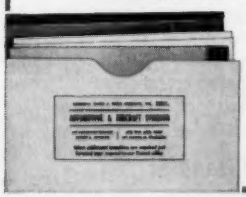
Selective Friction • Amount of friction can be changed to meet individual requirements. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment.



***PUSH*-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN**



• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

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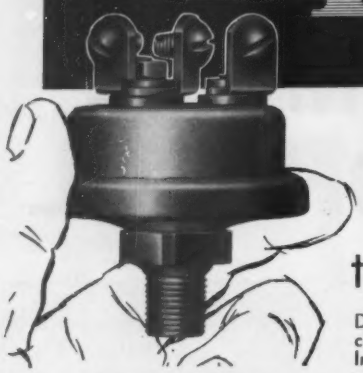
6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

ACCO

Hobbs DUAL CIRCUIT PRESSURE SWITCHES



Add a NEW DIMENSION to Pressure Activation!

DOUBLE DUTY! Disconnects one electrical circuit while placing the other in operation. Industry-approved for a wide range of applications in dual circuit activation of various types of instruments, warning signals, safety devices, fuel pumps — in many other ways for making and breaking circuits. Ideal for locking out a starting motor while the engine is running. Can be used with oil or air . . . or with standpipe, almost any liquid or gas.

- Non-ferrous pressure chamber
- Phosphor-bronze diaphragm
- Alloy contacts
- Preset at factory

Available in pound setting specifications in both circuits within ranges of 3-6, 7-14 and 15-60 psi. Compact — only 1-11/16" diameter. Pressure assembled and pretested at 150 psi. Designed for use on direct current.

A COMPLETE LINE OF PRESSURE SWITCHES

Also available — a wide selection of single circuit pressure switches. Built by the manufacturers of Hobbs Running Time Meters and Shock-Mounted Head Lights. Distributors in principal cities . . . Write for CATALOG PS605

Symbol of SW Excellence

John W. Hobbs Corporation
A DIVISION OF STEWART-WARNER CORPORATION
2051 YALE BLVD., SPRINGFIELD, ILLINOIS

Circle 357 on Page 19

Wolverine TOGGLE CLAMPS
Cost Less per Thousand Clamping Operations

Note These Important Features:

- HARDENED PINS and BUSHINGS
- HEAVY BODY SECTIONS
- BLACK OXIDE FINISH
- PINS RIVETED FLUSH
- DROP-FORGED ARM

Many Types to Satisfy Your Work Holding Needs

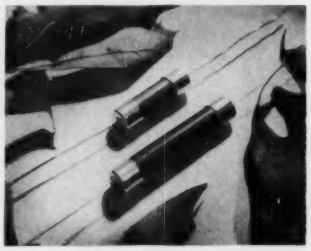
8 STANDARD ACTION UNITS
10 QUICK ACTION UNITS
12 PUSH ACTION UNITS & others

WRITE for CATALOG - PRICES - Template Sheets Available

WOLVERINE TOOL CO.
1242 E. WOODBRIDGE
DETROIT 7, MICHIGAN

Circle 358 on Page 19

nolic cartridge are now available. Cells are 0.010-in. aluminum stock, fitted into the phenolic housing like a stack of pennies in a paper tube; stacks are available with up to 500 cells. Cells operate at 130 C ambient temperature. A single stack used in a half-wave circuit accommodates 15,000 v and blocks a peak reverse voltage of 31,500 v. Phenolic housing has nearly twice the dielectric strength of glass melamine housing. **Rectifier Components Dept., General Electric Co.,** West Genesee Street, Auburn, N. Y.



Circle 567 on Page 19

Journal Bearings

have temperature range from cryogenic to +600 F

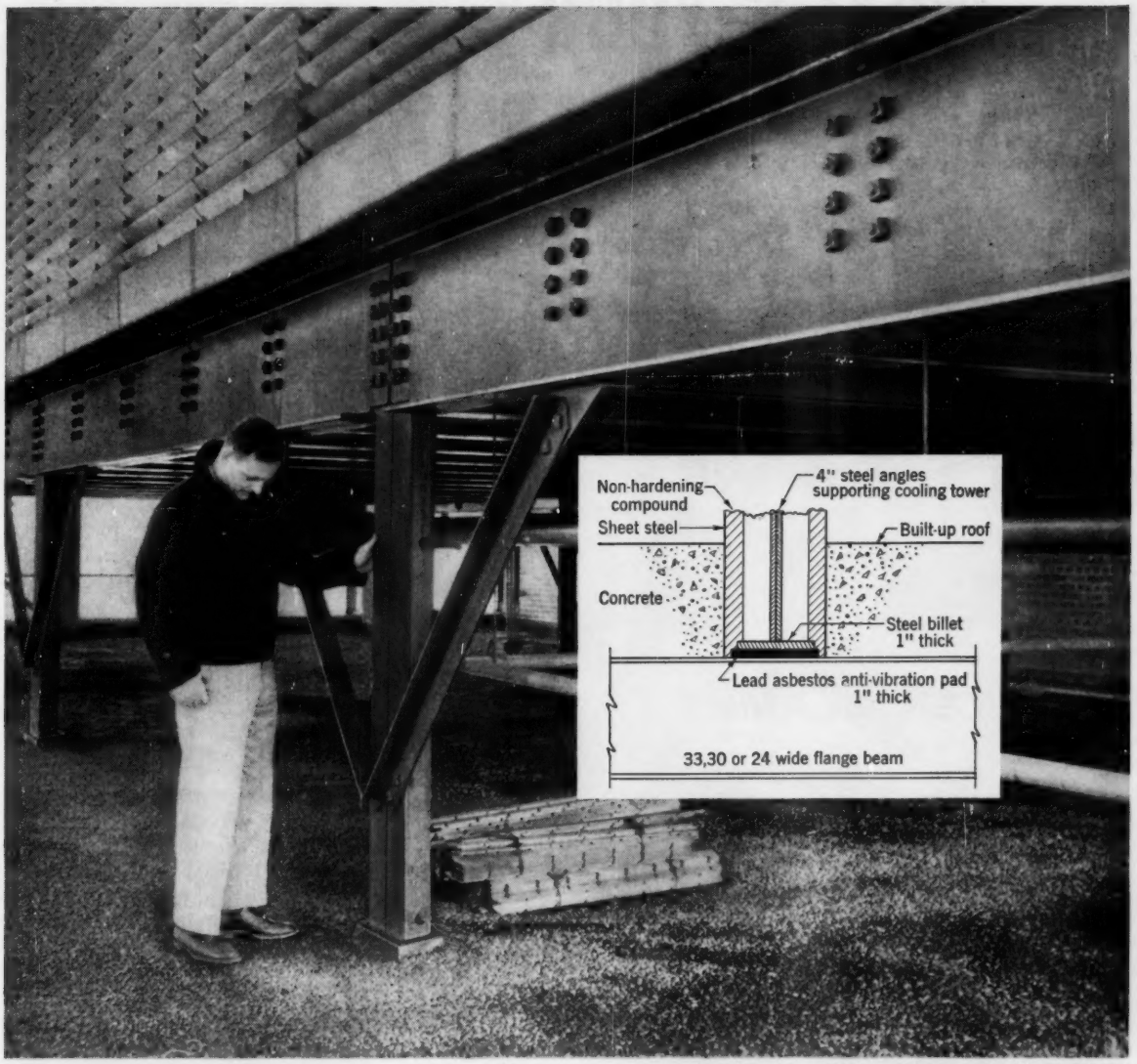
New plastic journal bearings are of Duroid 5813, a reinforced Teflon of high lubricity. Dirt, fibers, or debris will not adhere to them. Temperature range is from cryogenic to +600 F. Bondable to metal, bearings can be used to replace worn inserts in existing machinery or can be used without a metal backing as original equipment in new designs. While they can be bonded to any metal, dead-soft grades are most satisfactory. Other properties include: Thermal expansion equivalent to aluminum; no cold flow problems; no effect by moisture on dimensions. Bearings are available in conventional sizes. **Rogers Corp.,** Rogers, Conn.

Circle 568 on Page 19

Metal Pull Handles

of high-strength corrosion-resistant alloys

Produced in 3, 4, and 6-in. lengths, pull handles are available in stainless steel or aluminum, in either bright or nonreflective black finishes. They feature high-strength, corro-



Consulting Engineers: Weinberger, Frieman, Leichtman & Quinn
Architects: Sylvan Bien & Robert L. Bien

Machine vibration tamed with feet of LEAD

Give machinery in motion lead asbestos pads to stand upon, and a designer may have noise and vibration problems quickly under control. An example is the air-conditioning unit atop the new 35-story skyscraper at 575 Lexington Avenue, New York. Here lead asbestos pads just one inch thick, placed between the cooling tower and the building's structural steel, cushion the wide spectrum of noise and vibration created by the 205,000-pound unit and confine it to the tower.

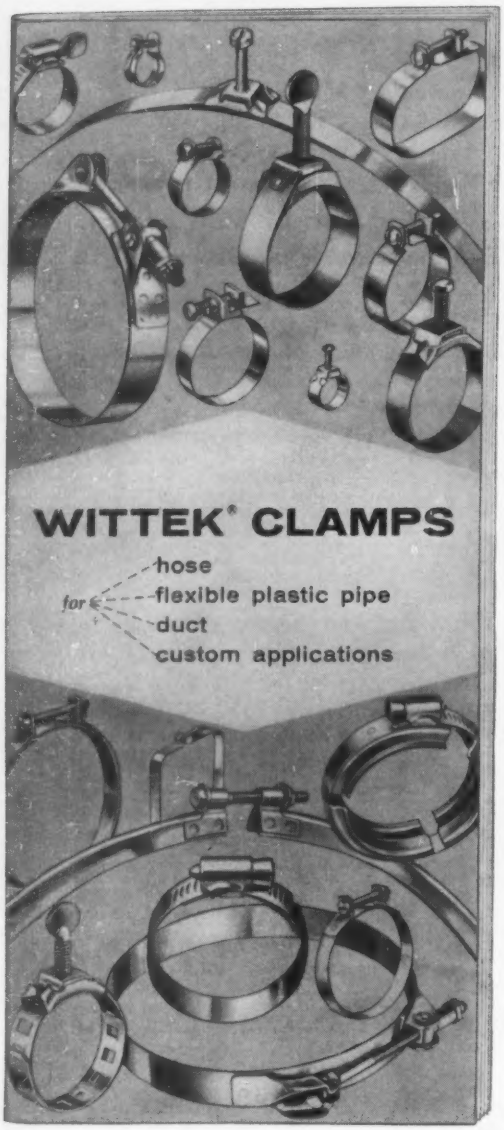
This use of lead asbestos also saved considerable time and money. Pads and supporting columns for the tower were positioned while major steel work was in progress. It was not necessary, as with usual methods, to wait until the concrete roof slab had been poured.

If *you* have a vibration or noise problem, perhaps the solution lies in one of the many forms of lead. We'd be more than pleased to help you find it. Just write to: Lead Industries Association, 292 Madison Ave., New York 17, N.Y. 3978

LOOK AHEAD WITH LEAD

Circle 359 on Page 19

WHAT'S YOUR CLAMPING PROBLEM?



WITTEK has the answer . . .

Whatever your clamping problem, it's a safe bet that Wittek has the exact type and size clamp to do the job. Write for this new 16-page brochure on standard Wittek clamps and custom-made clamps.

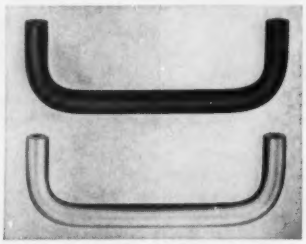
Quality Clamps for Over 35 Years

WITTEK Manufacturing Co.
4349 West 24th Place, Chicago 23, Illinois

CLAMPS *for Every Application*

8888

Circle 360 on Page 19



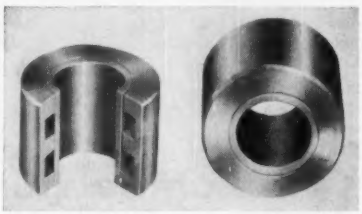
sion-resistant alloys treated for further protection in accordance with government specifications. Matching ferrules in each metal and finish are deep-drawn to provide support for heavy equipment loads. All handles are 5/16 in. diam, have a 1½-in. finger clearance, and minimum thread depth of ¾ in. Ferrules are 9/16 in. diam and 5/16 in. high. **Raytheon Co.**, Lexington 73, Mass.

Circle 569 on Page 19

Sleeve Bearings

have built-in oil reservoir

Neverlube bearings are available for light or moderately loaded applications inaccessible to regular lubrication, or where periodic lubrication is uncertain. Outer housing is cold-rolled steel; inner sleeve is sintered bronze. Built-in oil reservoir is filled during assembly. Capillary action through sintered-bronze bushing provides a continuous oil film between bearing, bore, and



shaft. Initial bore sizes range from ⅛ to 1⅜ in. Sizes of ½ in. and larger are interchangeable with certain standard sizes of needle bearings. **Carter Mfg. Co.**, Ferrysburg, Mich.

Circle 570 on Page 19

Resistor Networks

are made to tolerances of ±1 per cent

Hermetically sealed, thin-film, tin-oxide resistor networks offer high reliability, accuracy, and stability un-

PRODUCT-DESIGN BRIEFS FROM DUREZ

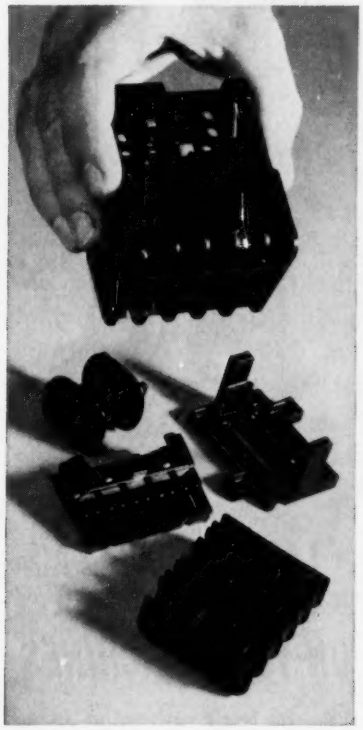
- **Choosing materials for a relay**
- **Building bigger plastic tanks**
- **Designing rust out of a pump**

Space saver

"Build a relay that's small enough to put in a topcoat pocket—and has the power rating of much bigger relays."

This was the challenge Westinghouse engineers faced. They met it with the help of low-cost Durez® phenolic molding compounds.

Five structural members of the new relay are molded from phenolic. All are excellent examples of the fine detail that's achievable with today's phenolics to help you save space.



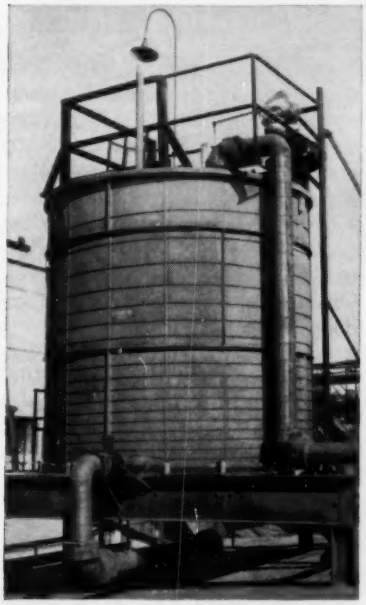
The relay's crossbar (left center), a moving part, requires extra strength in the contact supports. It is transfer molded from a Durez general-purpose compound that provides slightly higher-than-usual impact strength. Edges must be perfect, and very little flash can be tolerated.

All other parts are molded in *Durez 265 Black*, a general-purpose compound chosen mainly for its good moldability.

New twist in tanks

This concept in tank design mates the structural strength of steel with the corrosion resistance and fire retardance of Hetron® polyester-glass laminates.

The result is a very strong, durable tank that can be erected in virtually any size, with a safety factor of 40:1 or better. Besides being corrosion-resistant, the tank is free from galvanic action. Some tanks can be molded translucent, which eliminates the need for gauging. Marketed under the name "Kabe-O-Rap," the tanks are produced by Metal-Cladding, Inc., North Tonawanda, N.Y.



Factory-molded tank segments are made of Hetron resin reinforced with fibrous glass. A stainless-steel cable is wrapped helically around the plastic shell. The cable stabilizes the shell by taking up nearly all stresses transmitted by contained liquids.

This is one of many structural jobs for which designers are choosing Hetron, the inherently self-extinguishing polyester. You can find out all about Hetron and its uses by checking the coupon for a copy of the "Designer's Data File."

Super-tough plastic

This is part of a sump pump. It's the part you normally don't see—because it sits for months at a time in water that's dirty, oily, greasy, soapy, or just plain corrosive.

How, then, can the manufacturer of this pump—Bruner Corporation, Milwaukee—offer a "lifetime guarantee" that this housing won't rust or corrode?

Reason: it's molded of phenolic. No ordinary phenolic, but a high-impact glass-filled material, *Durez 16771*.

This phenolic permits close tolerances, because there's little or no molding shrinkage. The pump housing is rugged enough to support a ⅓-hp motor mounted over the center opening, and a 1¼" discharge pipe screwed into the hole at upper left. Corrosion tests of the housing indicate it will outwear all common metals, including stainless steel.

We're betting it won't be hard for you to think of places where *you* can use a super-tough, easily molded plastic like this. To help you do so, we've made available a 4-page illustrated bulletin, "Designing High-Impact Phenolic Molded Parts." It gives design rules based on latest experience. Use coupon to request a copy.

For more information on Durez materials mentioned above, check here:

- ☐ "Facts on Phenolics"—pocket guide lists properties of typical Durez molding compounds.
- ☐ "Designer's Data File" describes uses, advantages of Hetron polyester.
- ☐ "Designing High-Impact Phenolic Molded Parts"—4-page illustrated bulletin.

Check, clip, and mail to us with your name, title, company address.

DUREZ PLASTICS DIVISION

508 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

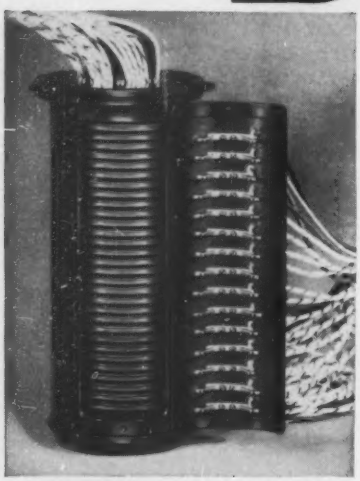
HOOKER CHEMICALS PLASTICS

Circle 361 on Page 19

COMPLETE SLIP RING ASSEMBLIES

Standard and Custom-Built

by SCP

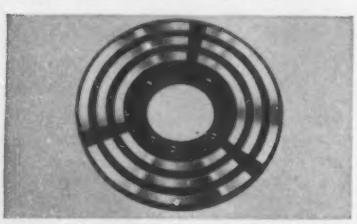


NO. SK-1334 STANDARDIZED CYLINDRICAL ASSEMBLY
15 TO 30 CIRCUITS

Diameter overall.....4½"
Height overall.....8¾"
Capacity.....2 amps, 250 v, 60 cy
R. P. M.....up to 1200

Stock delivery.

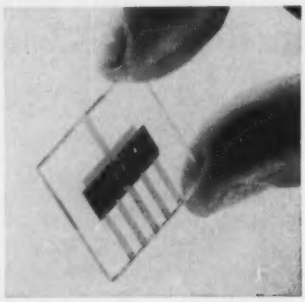
All phases of design and manufacture of slip ring assemblies are handled by the Superior staffs. All contact grades, plastic formulae, metallurgy, machining and assembly, pilot runs, and other steps are under the close scrutiny of highly trained personnel. Superior was the first to deliver the "complete package": engineering, contact and holder assembly, ring and complete final test of entire units. From Superior Carbon Products, you buy an unparalleled background in the field of slip ring assembly design and manufacture.



The second basic type, a pancake ring assembly, with segmented rings of varying diameters.

SUPERIOR CARBON PRODUCTS, INC.
SCP
9115 George Avenue • Cleveland 5, Ohio

Circle 362 on Page 19



der high temperatures. Any type circuit can be produced. Networks meet Mil Spec. 10509C. Thin films used have a basic resistivity of 100 ohms per square, and range of resistance values is from 50 ohms to 4 megohms. Temperature coefficient is ±50 PPM per deg C in production runs; lower temperature coefficients are available on special order. Tolerances are available to ±1 per cent. **Intellux Inc.**, 30 S. Salsipuedes St., Santa Barbara, Calif.

Circle 571 on Page 19

Flat-Wire Belts

of carbon, galvanized, or stainless steel

Flat wire belts are available in mesh sizes of 1 x 1, ½ x 1, and ½ x ½ in. Any width to 12 ft can be supplied. Belts are carbon, galvanized, or stainless steel. Wire widths and rod diameters can be varied to meet strength requirements, although standard width of wire is ⅜ in. Belting can be friction driven; however, a more positive drive and best belt alignment is obtained with the use of sprockets. Standard cast or machined sprockets in the size best suited to the belting selected are also available. **Cambridge Wire Cloth Co.**, Cambridge, Md.

Circle 572 on Page 19

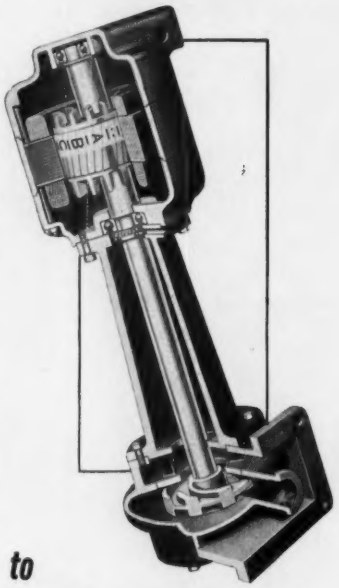
In-Line Removable Filter

has large filtering area

Design of the Nupro filter permits removal and replacement of the filter element without removing filter housing from the system. Filters have Type 316 sintered stainless-steel elements to prevent flaking, eliminating the danger of downstream contamination. Various micron-size elements to meet specific

Gusher

Coolant Pumps are PRECISION BUILT



to

• LAST LONGER
• PERFORM BETTER
ON YOUR MACHINES

You get better performance from your GUSHER Coolant Pumps because they are precision built. The one piece shaft in GUSHER Pumps is electronically balanced to cut vibration to a minimum. Ball bearings are pre-lubricated, no seal or packing needed. Write for catalog.

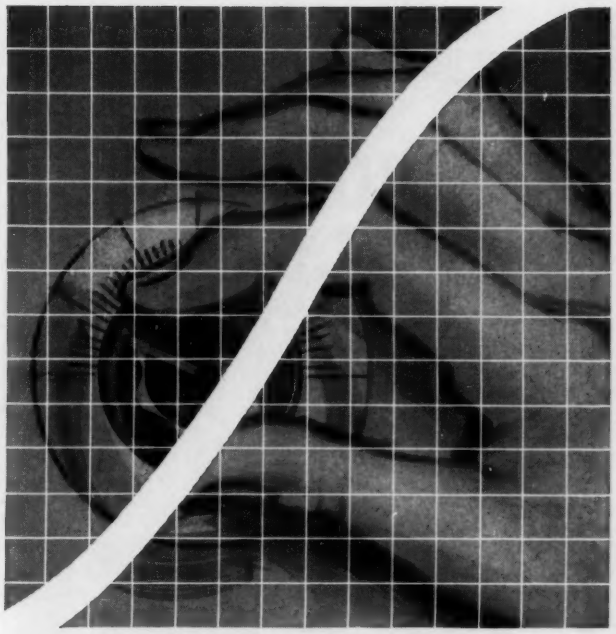
THE Ruthman MACHINERY CO.
• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road • Cincinnati 2, Ohio

Circle 363 on Page 19

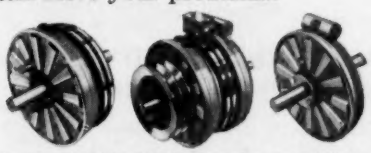
Warner electric brakes and clutches

with stepless torque modulation may be the answer to your drive problems



By simply varying the voltage to a Warner electric brake, clutch, or clutch-brake—you can have full-range stepless control flexibility. Just by turning a potentiometer dial on the Warner control, torque may be varied over a wide range during the first few seconds of engagement. Some companies offer adjustable torque as an extra feature for tailoring power characteristics to job requirements. Others have found it to be the solution to difficult control problems, such as synchronized engagement and disengagement of interrelated power drives.

Warner electric brakes and clutches are used for fast starting . . . synchronizing . . . automatic coupling . . . high-speed cycling . . . indexing . . . jogging . . . interlocking . . . and for scores of other power drive control applications. Write today—find out how they can solve your problems!



Primary clutches, clutch-brakes, brakes to 100 hp.

Warner Motor Brake

Warner Control Panel

example:

Two different braking torques from the same electric motor brake. When hoisting concrete blocks, not much braking torque is needed—yet when lowering pallets, a full braking action is necessary. Warner motor brake on this elevator drive may be actuated through either of two potentiometers. One is set at low voltage and the other at high voltage. Thus, two different braking torques are obtained by actuating the brake through relays, controlled by the *up* or *down* cycle of the elevator. Standard controls are used throughout.

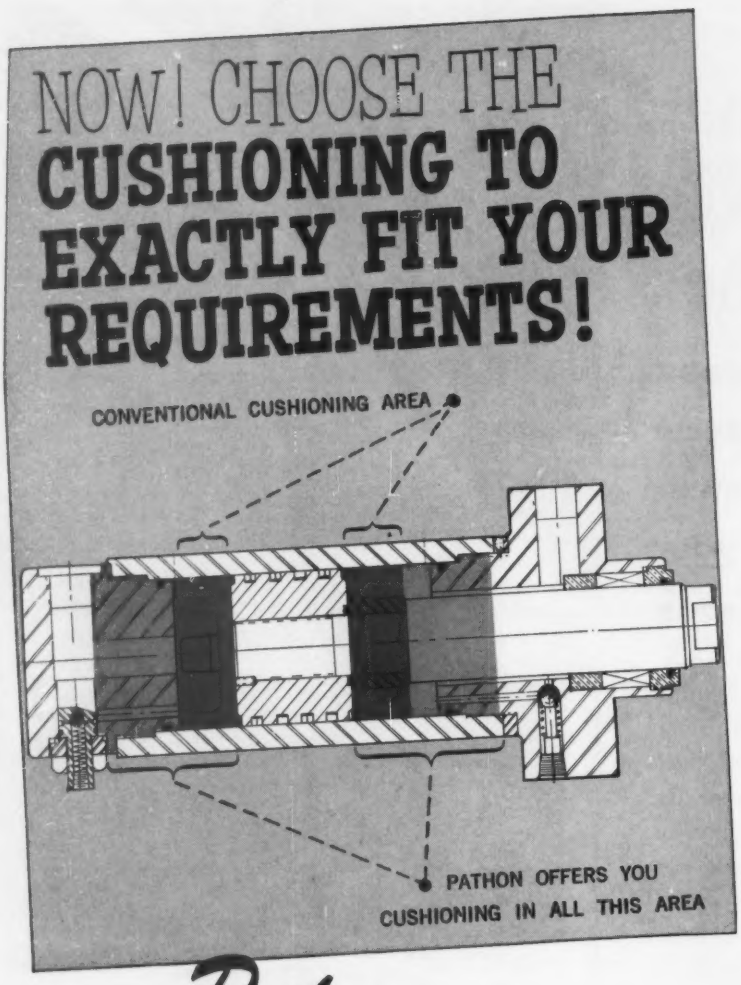
WARNER ELECTRIC

Warner Electric Brake & Clutch Co., Beloit, Wisconsin

Stocked by Distributors in Principal Cities Throughout the World

Circle 364 on Page 19

NOW! CHOOSE THE
CUSHIONING TO
EXACTLY FIT YOUR
REQUIREMENTS!



Another **Pathon** *First !*

High speed cylinder operations frequently require more refined deceleration techniques than ordinary cylinder cushions.

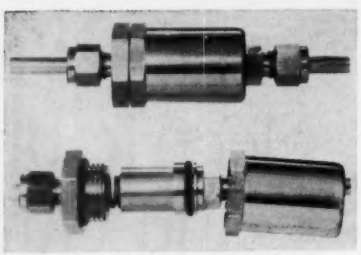
Now, Pathon cylinders are available with adjustable or non-adjustable cushions that are three to four times longer than ordinary cushions to provide the effective control required.

This extra length does not increase standard catalog dimensions and you can customs-specify any length or configuration up to the maximum.

Write for "LET'S TALK CUSHIONS" for details.

Pathon MANUFACTURING COMPANY
3823 Pacific Avenue, Cincinnati 12, Ohio

FLUID OPERATED AND CONTROL EQUIPMENT



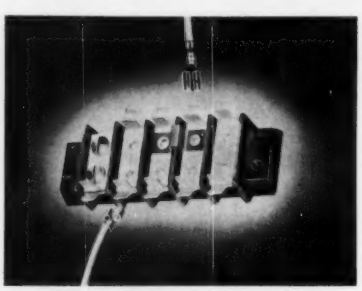
needs can be supplied. Filters are available in brass and Type 316 stainless steel with Buna-N or Viton-A O-rings and rubber gaskets, and Swagelok tube-fitting connections. **Nuclear Products Co.**, 15635 Saranac Rd., Cleveland 10, Ohio.

Circle 573 on Page 19

Terminal Blocks

incorporate positive quick disconnect

Self-locking, quick-disconnect wire terminations on terminal blocks make possible up to six connections at each stage. Variable-angled tabs, called Kliptite, accept various female wire terminations supplied either singly or in rolls for automatic machine assembly. Blocks are widely used in appliance, air-conditioning, vending machines and other types of equipment manufacturing, or in any application that



requires positive, quick-disconnect. Kliptite terminations also are available with toggle switches and convenience outlets. **Kulka Electric Corp.**, 633-643 S. Fulton Ave., Mount Vernon, N. Y.

Circle 574 on Page 19

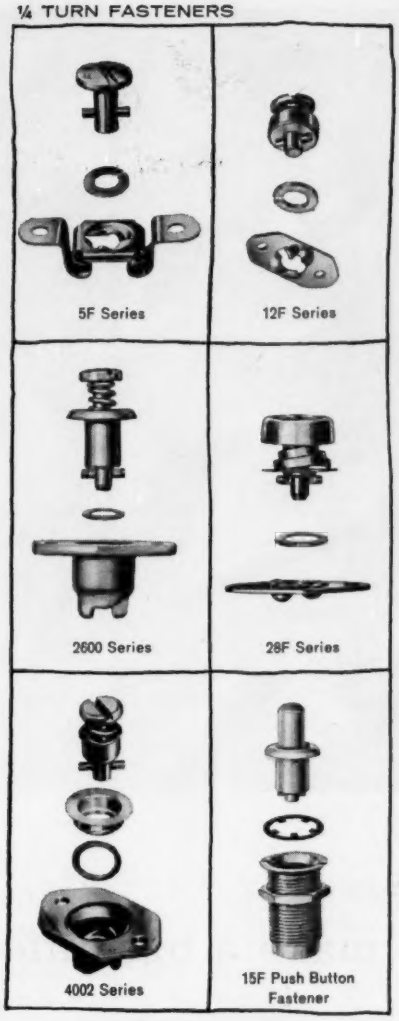
Nylon Grommet

fits 10 to 24-gage steel or aluminum sheets

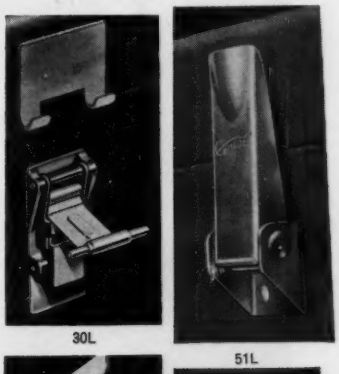
Pipcat nylon caterpillar grommet, available from stock in three sizes,

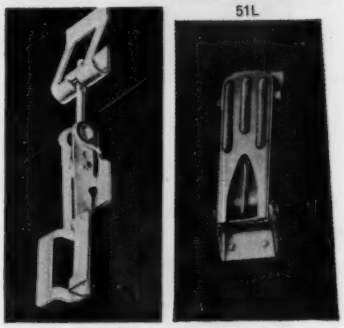
Circle 365 on Page 19

¼ TURN FASTENERS



UNIVERSAL LATCHES





CHASSIS LATCHES

HARNESS CLAMPS

FASTEN/ATION The mechanics of modern fastening have matured to the point where it is now considered a science. We call it FASTEN/ATION.

Your designs are important enough to build, and should be covered and protected . . . but you must be able to remove the covering in a hurry. Here's where Camloc's FASTEN/ATION becomes significant to you. Installation is simple – closure is simple – opening is even simpler, and each of these operations takes only seconds.

The final touch to a good design includes the best method of fastening, the simplest installation and use, and a fastener that complements the product in size and appearance. Since making a decision involves the evaluation of alternatives, here are some of Camloc's more popular fasteners. We know you will want to make a more careful analysis before you specify, we suggest that you write for our complete catalog. Be FASTEN/ATED! Let us FASTEN/EER your next design.

specialists in fasteners for industry

CAMLOC®

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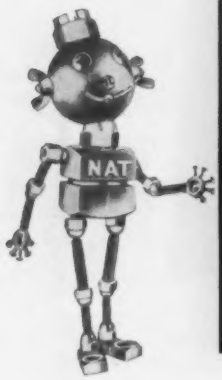
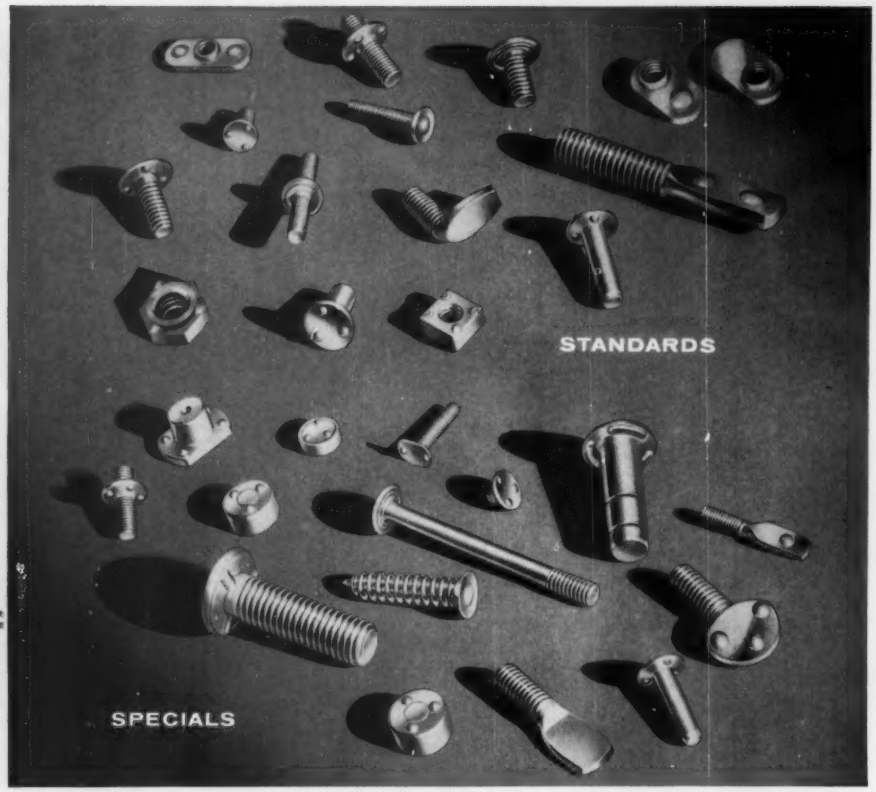
West Coast Office, 5455 Wilshire Blvd., Los Angeles, California • Southwest Office, 2509 W. Berry St., Fort Worth, Texas
European Subsidiary: Camloc Fastener GmbH, Kelkheim/Taunus, West Germany

NAT'S
quick facts
about
Fasteners...





Welding Fasteners...

the little things that make a big difference

Welding Fasteners put threads into the most unlikely places, and make light of the weightiest assembly problems.

Where hands and wrenches can't get in, for instance, or where material dimensions or contours make it next to impossible to use regular fastening methods, Weld Nuts or Weld Screws neatly side-step the difficulties . . . and make assembly simple, fast and foolproof.

We could go on and tell you more about Welding Fastener advantages . . . in improving product design and quality, increasing production efficiency, and cutting costs . . . and we'll be very glad to, if you like.

Right now, though, we'd just like to say that when you need certain standard Weld Nuts or Weld Screws, and you want to be sure they're designed right and made right . . . that's where we come in. We *know* Welding Fasteners, and we *stock* many of the most commonly used.*

We might just mention, too, that we happen to be particularly adept at developing Special Fasteners for welding. They can often be designed to do a better job and save money for you. Ask us about your applications.

*Standard types and sizes are illustrated and listed in National's booklet on Welding Fasteners. Write for your copy.

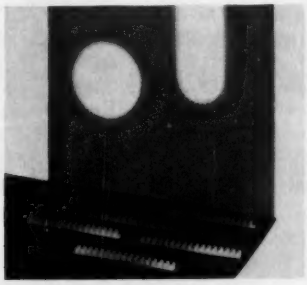
National PRODUCTS

The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

Circle 367 on Page 19

can be supplied to fit 10 to 24-gage steel or aluminum sheets. As the standard length is 10 in., fabricator need only cut to the required length. Unit is used for insulating holes of over 3-in. diam and can be used in combination to fit any size hole. For square or round holes of over 6-in. diam, commercial solvents may be required to hold it to metal. For smaller sizes, tension is adequate to hold to any surface.



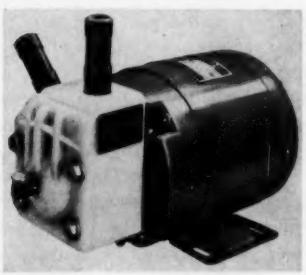
Material meets MIL-P-17091-B, latest revision. **Plastiglide Mfg. Corp.**, Dept. P-2, 1757 Stanford St., Santa Monica, Calif.

Circle 575 on Page 19

Plastic Pump

has no stuffing boxes or shaft seals

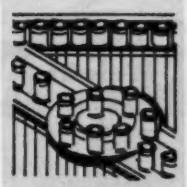
Compact, close-coupled, Flex-i-liner plastic pump is available for such applications as vending machines, plating equipment, lube-oil service, bottle fillers, and laboratory equipment. Pumping is accomplished by a rotor on an eccentric shaft, which turns within a flexible liner. This creates a progressive "squeegee" action on fluid trapped between the synthetic liner and the plastic body block. There are no stuffing boxes, shaft seals, valves, or gaskets, and no contamination of the material being pumped. Pump is self-priming, operates wet or dry, and handles slurries and viscous materials.



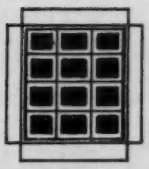
Whatever your driven machine,
you save it from RUIN
every time this clutch cycles . . .

HILLIARD
Adjustable
Slip Clutch

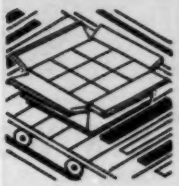
- Safely limits torque
- Protects against overload-jams – downtime
- Resumes drive automatically after overload
- Eliminates shear pins and lost time
- Adjustable-while-running feature available



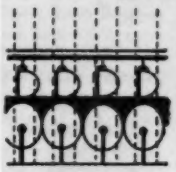
PACKAGING MACHINES



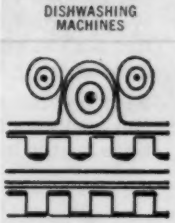
CASE LOADERS



CONVEYORS



DISHWASHING MACHINES



PRINTING PRESSES

"Value is related to function—not to cost."

Hilliard Slip Clutches give you continuous, positive, and reliable protection of drives on packaging machines . . . case loaders . . . conveyors . . . dishwashing machines . . . printing presses . . . circuit breakers . . . and many others.

They also maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

Adjustable-while-running types maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

Write for Bulletin 300 for complete details.

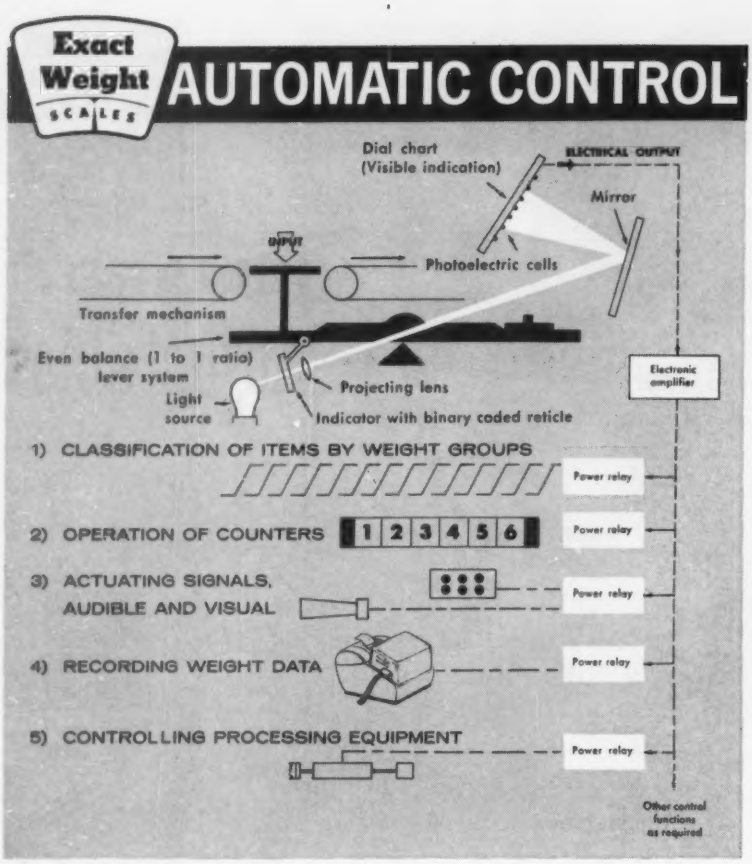
Remember, HILLIARD is your Industrial Clutch specialist . . . for more than 55 years . . . and the line includes Over-Running Clutches, Intermittent Drive Units, Single Revolution Clutches, Hilliard-Twiflex Centrifugal Coupling.

Manufacturing Clutches for over 50 years

THE HILLIARD CORPORATION

103 W. FOURTH ST. ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.



This weight-sensing principle may solve your design problem

If your product involves automatic control — processes, quality or costs — the Exact Weight principle of weighing or measurement of force may help solve your problem.

This precision weighing system, using photodiodes arranged to read deflections of a light beam, automatically supplies electrical output signals for a variety of sorting and control devices. Today, the Exact Weight principle is being used for positive control of basic operative functions in many types of automated machines including packaging, metalworking, textiles and plastics weighfeeders.

Send us your application requirements — or any weighing problem. Our engineers will gladly cooperate with you and make recommendations for the most economical solution.

NEW REFERENCE MANUAL
Here is a source of helpful design ideas showing various applications of weight sensing used in control functions. It is available free. Write for your copy today.

Exact Weight SCALES

THE EXACT WEIGHT SCALE CO.
623 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: 5 Six Points Road, Toronto 18, Ont.

Circle 368 on Page 19

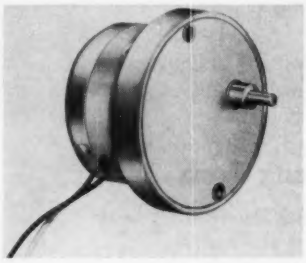
Standard unit is available in capacities from 1/3 to 10 gpm and pressures to 35 psia. Standard materials are high-temperature neoprene for the liner and linear polyethylene for the body block. Pump is available with a choice of standard industrial motors. **Vanton Pump & Equipment Corp.**, Hillside, N. J.

Circle 576 on Page 19

DC Motors

offer full ac-dc interchangeability

Series 310 DC motors are suitable for continuous duty from no load through 20 oz-in. at 1 rpm, and are available in standard shaft configurations. Designed primarily as motion display units, they are also a source of power for low-duty cycle or short-life commercial applications. Speeds range from 4/5 to 1800 rpm, and units have full ac-dc interchangeability. Motors are self-starting and are powered by two or more standard flashlight batteries. Units are reversible for clockwise or counterclockwise rotation. Low battery drain assures long battery life. **Bristol Motors, Div., Vocaline Co. of America Inc.**, Old Saybrook, Conn.

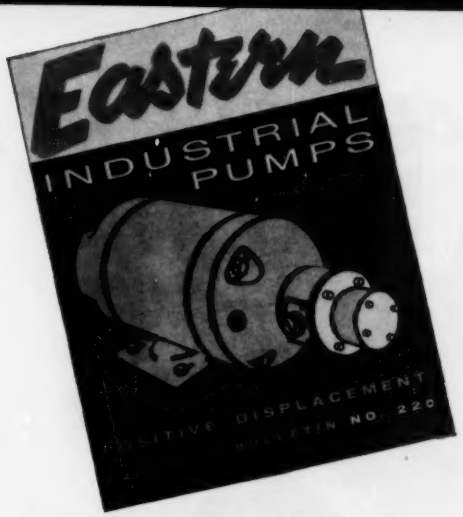


Circle 577 on Page 19

Self-Tapping Insert

action prevents formation of chips

SpeedSert self-tapping insert permits speedy installation of strong threads in plastics, aluminum, and magnesium alloys, and other relatively soft materials. Wave form threads, extending the entire length of the insert except for end chamfers, roll their way with a zero tolerance fit through the base material without cutting, preventing the



EASTERN takes the gamble out of selecting

POSITIVE DISPLACEMENT PUMPS

If you have a performance requirement for pumps which can deliver a pulsation-free flow of non-lubricating liquids at pressures up to 200 psi on the gear type or rates up to 6 gallons per minute on the vane type, pick a winner from the big Eastern line.

For small volumes against relatively high pressures, the Eastern GW series gear pumps are a natural. In each pump, oversized bearings of impregnated graphite support a drive gear of stainless steel and an idler of special bronze material. These self-priming units require no lubrication and cannot contaminate the liquid being pumped.

For volumes from 1.5 to 6 gpm and pressures to 60 psi, you can't beat Eastern VW series vane pumps. These highly efficient units are designed around a cam-shaped pumping chamber assuring pulsation-free liquid flow. Vanes are held in positive contact with the pumping chamber at all times — and their positioning is independent of hydraulic pressure or centrifugal force. Composition carbon graphite bearings and vanes require no lubrication beyond that of the liquid being pumped.

All Eastern positive displacement pumps are close-coupled with motor or can be furnished less electric motor with belt stand for belt or coupling drive.

Don't make your points the hard way — play safe and write for Eastern's new Bulletin 220 on positive displacement pumps.

Other Eastern products:

- ***hydraulic motors***
- ***gear pumps***
- ***centrifugal pumps***
- ***aircraft pumps***

EASTERN INDUSTRIES ★ PUMP DIVISION ★

EASTERN INDUSTRIES INCORPORATED

Hamden, Connecticut

Circle 369 on Page 19

SCOTT
OUTBOARDS

VICTOR-Sealed Right and Tight!

For maximum power output . . . efficient carburetion and cooling . . . tight lubricant retention and water exclusion . . . Scott Outboard Motor engineers specify these typical high-quality Victor gaskets and oil seals:

- **VICTOCOR®** soft-packing, metal-core, cylinder head gasket
- **VICTOPLATE** fiber and synthetic rubber shim gasket
- **CORBESTOS®** steel-core asbestos power head adapter gasket
- **VICTOPAC®** asbestos-synthetic rubber cover plate gasket
- **ASBESTOPAC®** asbestos-synthetic rubber drain cover gasket
- **VICTORITE®** treated plant-fiber packing carburetor adapter gasket
- **Type K31 VICTOPRENE®** limited-space application oil seal for water and bailer pumps
- **Type K4 VICTOPRENE®** dual-lip oil seal for propeller shaft and crankshaft

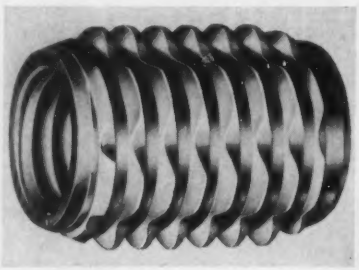
Marine Power Sealing—a VICTOR Specialty
. . . WRITE FOR CATALOG

In standard gasket and oil seal designs, Victor gives you widest selection in all types. In nonstandard equipment, Victor offers 50 years' leadership in design, development and manufacturing. Comprehensive engineering catalogs supplied free. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian plant: St. Thomas, Ontario.

VICTOR

Sealing Products Exclusively
GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS

Circle 370 on Page 19



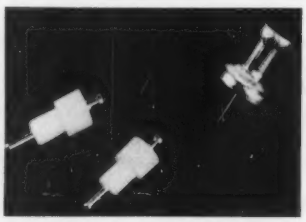
formation of chips. Base material is pushed back gently, and then returns behind the wave crest to lock the inserts from backing out. Inserts of case-hardened carbon steel, cadmium plated, sizes 4-40 (SP 0440) through ¼ (SP 420 or PS 428) are available from stock. **SpeedSerts Inc.**, 6500 Avalon Blvd., Los Angeles 3, Calif.

Circle 578 on Page 19

Teflon-Insulated Terminals

withstand temperatures from −100 to +250 C

Included in new line of Teflon-insulated terminals are miniature and subminiature stand-offs and feedthroughs, receptacles, plugs, jacks, and probes. Uncontaminated Teflon is used for the insulating bushing. All terminals withstand temperatures from −100 to +250 C, and resist rough handling or vibration. They are corrosion-resistant and remain unaffected by solvents, acids,



or bases. In addition to white Teflon, terminals are available in a variety of colors for color coding. **Microdot Inc.**, 200 Pasadena Ave., South Pasadena, Calif.

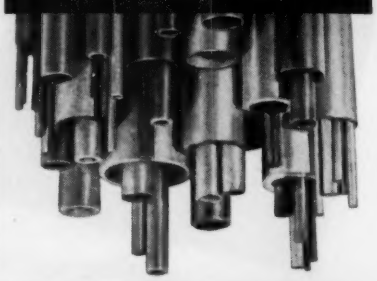
Circle 579 on Page 19

Check Valve

of all Pyrex and Teflon construction

Model SL 200 spring-loaded check valve is for horizontal and vertical mounting. Pyrex and Teflon con-

NOW



fine tubing in columbium and tantalum

You can now get fine, seamless tubing in columbium and tantalum from UNIFORM TUBES and profit from UNIFORM's standard policies of (1) top quality, (2) close tolerances, (3) fast delivery and (4) low prices. Drawn to your specifications with tolerances of ± 0.0005″ or better, columbium and tantalum tubing is available with any specified O.D. from 0.010″ to 0.500″. Wall thicknesses range from 0.065″ to 0.001″ with equally close tolerances.

Although drawn specially to your order, columbium and tantalum tubing will normally be shipped within 2 to 3 weeks.

This tubing is offered in random straight lengths to 20′ or cut to specific lengths, free of burrs. For subsequent ease of fabrication, tube lengths are fully annealed in vacuum furnaces. If you prefer, UNIFORM will fabricate columbium and tantalum tubular parts for you with the same skills and care that enable us to draw the original tubing to such close tolerances. Besides placing full responsibility with one supplier, you get the advantages of UNIFORM's low prices when tubular parts are fabricated "at the mill."

If you use or specify columbium or tantalum for their high-temperature strengths, corrosion resistances to hot acids, molten metals and metallic salts, or for their other outstanding properties, then write today for details on fine seamless tubing and fabricated parts of these rare metals.

UNIFORM TUBES, INC. COLLEGEVILLE 2, PA.
HUxley 9-7276 TWX-CGVL 1044

Circle 371 on Page 19

INDUSTRIAL RETAINING RING PRICES REDUCED UP TO 51%

Series 1000, Series 3000 and Series 3100 Industrial Retaining Ring prices—in quantities up to 100,000—have been greatly reduced.

Thanks to modern, efficient production methods you can now get these Industrial Retaining Rings—either pre-stacked or bulk packed—at new, low prices . . . and pay less for pre-stacked rings than you have been paying for bulk packed. Reductions apply to standard materials and finishes.

Use this coupon to send for your new, revised IRR Price List.

INDUSTRIAL RETAINING RING COMPANY

Please send me, free, a copy of the new 1961 IRR Price List – 6 1M.

_____I would also like to have your representative call.

Name_____Title_____

Company_____

Address_____

City_____Zone_____State_____

IRR *Originators of modern retaining ring dispensing*

INDUSTRIAL RETAINING RING COMPANY

57 Cordier Street, Irvington 11, New Jersey

Circle 372 on Page 19

Why design to a proprietary standard?

Compare overall stack heights shown in the table below, and you'll see what we mean. Listed are so-called "standard" heights of ¼" 3-ring fabricated "V" packings offered by six major manufacturers. Overall heights range from a low of ⅝" up to 1 9/64" high . . . *a variation of more than* ½".

COMPARATIVE STACK HEIGHT OF FABRICATED "V" PACKINGS PLUS ADAPTER NOW OFFERED

C/S	SOURCE	3/SET
¼"	Mfgr. A	25/32
	" B	41/64
	" C	1 9/64
	" D	45/64
	" E	5/8
	" F	23/32

This means that in laying out a gland for fabricated "V" packings, the designer must first determine which manufacturer he wants to buy from before he completes his design. And once the gland is made for this particular brand of packing, replacements of the same brand are almost mandatory. Another handicap—switching to a leather or homogeneous packing later would be extremely difficult because of the difference in stack heights.

The use of Standard J.I.C. stack heights for fabricated "V" packings is the obvious answer to this problem. Yet, today Houghton is the only packing manufacturer who offers you uniform stack heights for *all three* major "V" packing materials—fabricated, homogeneous and leather—making them interchangeable with respect to dash number, O.D., I.D. and stack height.

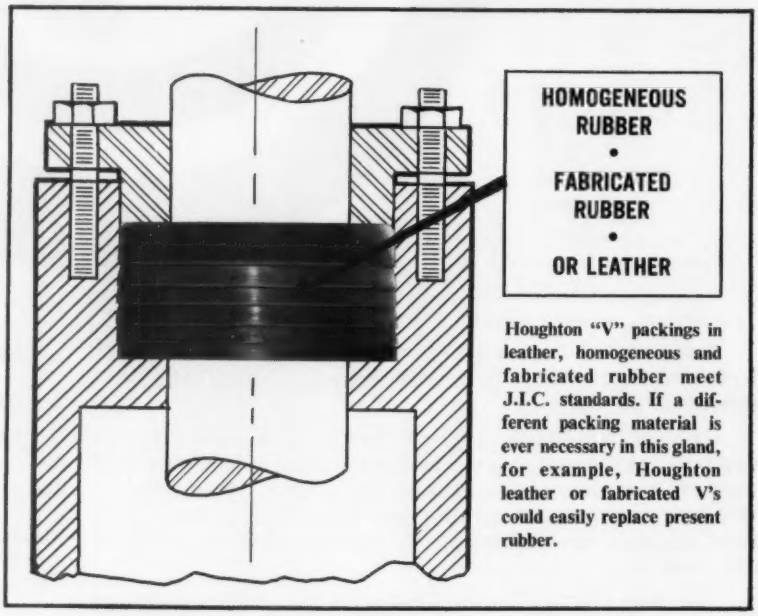
With Houghton "V" packings, you don't have to compromise in material to meet your operating requirements. Simply select the material best suited to the job and you know it will fit automatically.

Complete interchangeability among Houghton leather, rubber, and fabricated "V" packings is the solution to a long-standing problem—the choice of material for an application that demands properties no single packing material can provide.

Now, the identical stack heights of all Houghton V's permit *unlimited* switching of V combinations in any gland, either with rings of the same material, or different materials within a set.

You can use a leather V for anti-extrusion, strength, and low friction with rubber rings for wiping efficiency and low cost. You can switch from homogeneous rubber to fabricated to gain extra strength. You can even use V's of all three materials in the same gland.

Leadership in packing standardization is another reason major hydraulic and pneumatic equipment manufacturers consider Houghton "packing headquarters". Houghton is also the only manufacturer who offers a *complete* line of packings and fluids for almost any industrial hydraulic system. This experience in both fields is your guarantee of a completely unbiased recommendation of compatible materials . . . the very best for your particular application. For more information or help, call or write: E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.

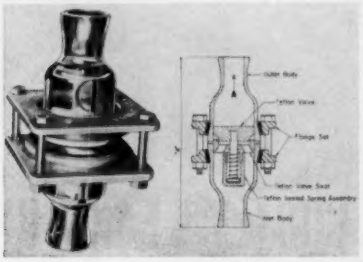


Houghton "V" packings in leather, homogeneous and fabricated rubber meet J.I.C. standards. If a different packing material is ever necessary in this gland, for example, Houghton leather or fabricated V's could easily replace present rubber.

Houghton

INDUSTRY'S PARTNER IN PRODUCTION

struction insures full visibility with corrosion resistance to all liquids except hydrofluoric acid and hot concentrated caustics. Stainless-steel spring is sealed from liquids and gases by a Teflon enclosure. Positive sealing is guaranteed by a lip seal on the seat. Valve is available in 1, 1½, 2, and 3 in. sizes, adaptable to any pipe installation with 150-lb ASA companion flange. Maxi-



mum operating pressure is 50 psi except for the 3 in. valve, rated at 35 psi. **Chem Flow Corp.**, 165 Paterson Ave., Little Falls, N. J.

Circle 580 on Page 19

Binding Posts

have plastic molded parts

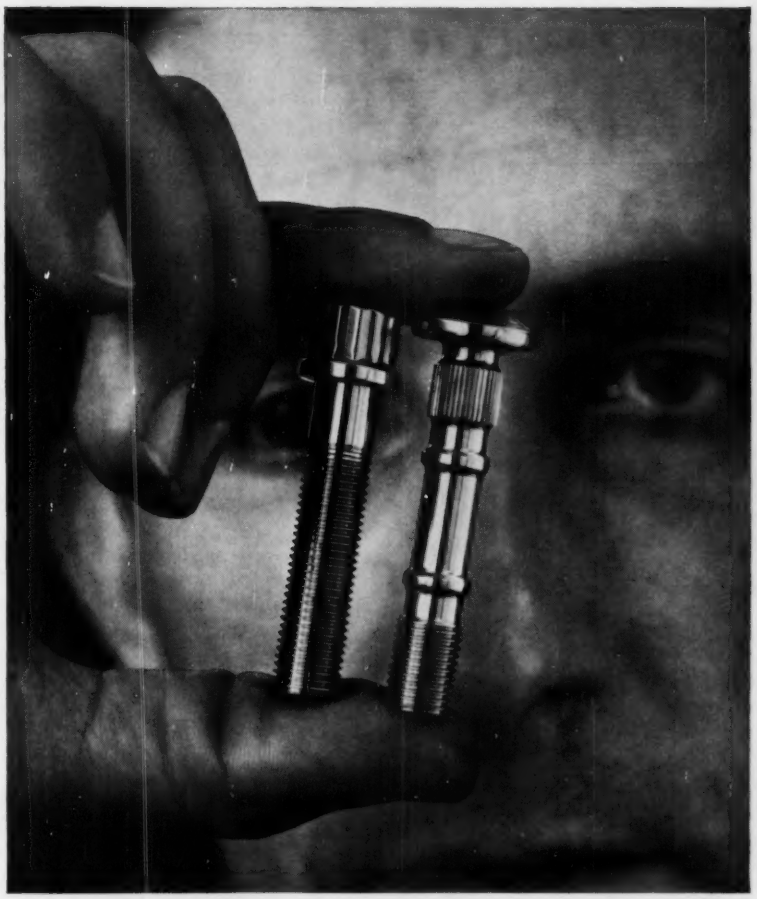
Fluted nut, five-way binding posts incorporate Lexan polycarbonate resin molded parts. Tough, rigid thermoplastic polymer provides low loss and power factor; low dielectric constant; high voltage insulation; high impact strength over a range from less than −100 to +275 F; heat resistance with a distortion point as high as 290 F; dimensional stability; high gloss. Binding posts are rated for a current capacity of 30 amp and a working voltage of 1000 v. **Superior Electric Co.**, Dept. LBP, Bristol, Conn.

Circle 581 on Page 19

Cable Clamps

are neoprene-coated aluminum

Two styles of metal clamps have been added to a line of plastic clamps for cord, cables, and tubing. Made



10426-CH

How *critical* can you be in your selection of a fastener for a special application . . . especially when extreme accuracy, reliability and consistent performance are specifications. For over thirty years, Chandler has been producing special fasteners and standard cap screws and bolts that meet these demanding requirements.

If you have a special fastener problem . . . here's what you can expect from Chandler. *Into the design* of your special fastener goes the knowledge of expert Chandler engineers . . . careful attention to detail and exhaustive testing to meet critical standards . . . advanced production methods to assure on-time delivery . . . RESULT . . . a precise fastener, custom-tailored and mass-produced at the most favorable cost.

Next time . . . Check with Chandler . . . FIRST.

Write today for your Chandler catalog.

CP

chandler Products Corporation

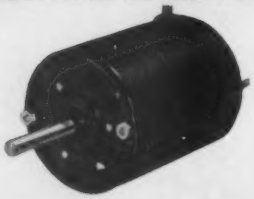
1494 Chardon Road • Cleveland 17, Ohio

Circle 374 on Page 19

versatile

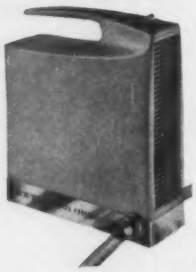
HEINZE

B



MOTOR

powers portable pump



Here's just one example of the versatility of the Heinze B Universal Motor — operating at 2500 rpm, 1/40 hp, 4V DC, to power this compact portable pump manufactured by the Russell Harrington Cutlery Company, Southbridge, Mass.

Because of its versatility, the B Motor is ideal for such applications as rug cleaners, toy automobiles, electric brooms, vacuum cleaners, and power tools. Horsepower ratings may be supplied from 1/40 to 1/3. Load speed can vary from 2500 to 20,000 rpm. Voltage ratings range from 4V to 220V, AC, DC or AC/DC. Motor is furnished in steel or die cast case.

WRITE FOR COMPLETE INFORMATION.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Dept. D
SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Circle 375 on Page 19

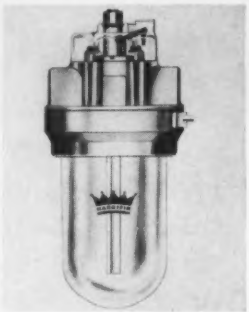
of aluminum, Type NE clamps are easily assembled and are free from rust. Flame-resistant neoprene cushion, because of high friction coefficient, holds cord or tubing with a positive, nonsliding grip that prevents any strain on connections. Because of cushioning action, cutting and scraping of cord insulation are minimized. Clamps are available in sizes for 1/8 to 2 in. cable in 1/16-in. increments. **Richco Plastic Co., Dept. MD-1**, 3722 W. North Ave., Chicago 47, Ill.

Circle 582 on Page 19

Air-Line Lubricator

for service to 150 psi

Compressed air-line lubricator incorporates a transparent dome that permits view of the changing oil delivery rate as it is manually adjusted. Lubricator is offered in 1/4, 3/8, 1/2, 3/4, and 1-in. pipe sizes for service to 150 psi. It provides oil



delivery in applications that move as little as 1 to 2 cu ft of air per min. A 0.4-lb pressure drop is needed to start oil feed. Inlet and outlet ports are interchangeable. Bowl can be filled quickly through a large opening in the top of the body without shutting down the supply of air. **Hannifin Co., Dept. 116**, 501 S. Wolf Rd., Des Plaines, Ill.

Circle 583 on Page 19

Pushbutton Switch

has snap drive for positive operation

Prestressed, coiled-spring toggle mechanism in the actuator of the Type 25J6-1D snap-drive pushbutton switch gives fast, positive operation regardless of the rate at

STOP!

COSTLY LEAKS OF VALUABLE FLUIDS

WITH

DURA SEAL

THE ENGINEERED MECHANICAL SEAL

Savings in product alone will repay the cost of Dura Seal installation

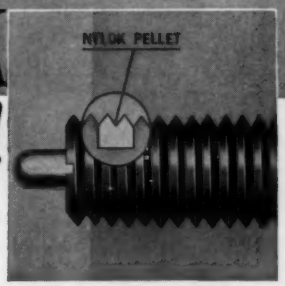
For further information, write for free Bulletin No. 480 MD

The PERFECT SEAL
TRADE MARK

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Circle 376 on Page 19

NOW all VLIER Spring Plungers are available with NYLOK at no extra cost!



Nylok-fitted bodies are self-locking; eliminate need for checknuts or other secondary locking devices.

Whether you use Vlier Spring Plungers on tooling, or for original equipment applications, you'll like this new self-locking feature.

Each Vlier Spring Plunger body is permanently fitted with a tough, resilient nylon pellet which slightly protrudes above the major thread diameter. As the plunger is inserted in the tapped hole, this pellet is *compressed* (not cut), exerting a spring-like pressure on one side of the plunger body. This *constant* lateral thrust wedges the mating threads together, assuring a *positive* lock that remains vibration-proof regardless of cyclic loads.

PERFECT FOR USE WHERE PERIODIC ADJUSTMENTS MUST BE MADE—The self-locking feature is effective whether the body is seated or not, permitting the Vlier Spring Plunger to be easily and accurately adjusted as required... cannot back off or be shaken loose once set.

RE-USEABLE MANY TIMES—When the Vlier Spring Plunger is removed, the Nylok pellet strives to return to its original shape. Parts can be used numerous times before any locking pressure is lost.

NO EXTRA COST FOR SELF-LOCKING FEATURE—All standard Vlier Spring Plungers are now available with the self-locking feature at no increase in price! However, all models may still be ordered without Nylok.

Your Vlier distributor now has Nylok-fitted Vlier Spring Plungers on his shelf. Order a supply today.

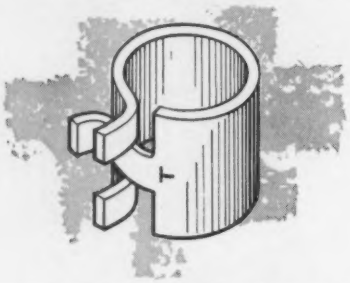
VLIER
Engineering Corporation
A subsidiary of Barry Wright Corporation
8900 Santa Monica Blvd., Los Angeles 46, California

INFORMATIVE NOTES TO IMPROVE YOUR PRODUCT ...SAVE YOU MONEY

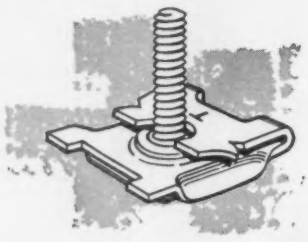
Published as a service to Designers and Engineers

Ideas from Tinnerman have cut costs, improved products. Here are examples from Tinnerman's 10,000 variations of SPEED NUT brand fasteners —all stamped with the T-mark of *total* reliability.

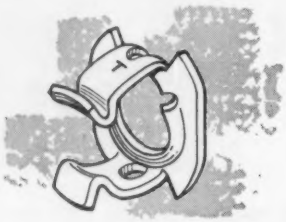
Tinnerman can help *you* cut costs with a free Fastening Analysis of your product. Call your Tinnerman representative, or write: *Tinnerman Products, Inc., Department 12, P. O. Box 6688, Cleveland 1, Ohio.*



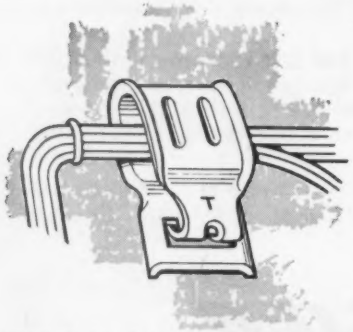
VERSATILE COMPRESSION RING has solved fastening problems in car radios, pressure gages, washers, and speaker cabinets. Simply squeeze compression fingers with pliers to expand . . . release, and spring tension maintains firm connection. Heat-treated spring steel of this SPEED CLIP® fastener won't lose tension, won't loosen under vibration. Possible applications are practically unlimited.



BOLT RETAINER used to fasten grille extensions to car fenders, has potential usage in any field where high-torque fastening is required on thin metal sections. This SPEED GRIP® fastener eliminates costly welding or staking, speeds assembly, allows savings in labor costs and parts handling. Barbs locate fasteners until nut is driven. One of Tinnerman's extensive line of SPEED GRIP nut and bolt retainers.



ELECTRONIC CONTROL CLIP retains tuning switch on chassis, gives constant spring tension for both push-pull and revolving controls . . . can be used wherever electronic controls are installed. This multipurpose SPEED CLIP fastener replaces threaded nuts, bushings, lockwashers. Cuts costs substantially. Live spring action lasts for the life of the equipment.



WIRE RETAINER is ideal for attaching single wire, light harness, cables or tubing. This SPEED CLIP fastener can be preassembled on the harness, allowing an entire wiring system to be snapped into place in seconds. Double embosses on upper clamping leg trap cold-flow tendencies of vinyl covered cord, assure 35 pound pull resistance. Clip will accept any wire or bundle up to .306" x .515".

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Simmonds GMBH, Heidelberg.

TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

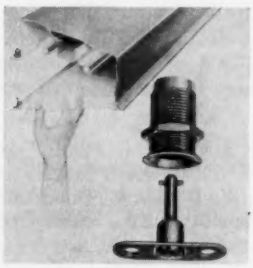
which operating force is applied. Switch gives momentary-contact DPDT circuit control at loads of 5 amp, 125/250 v ac, 5 amp, 30 v dc resistive, or 3 amp, 30 v dc inductive. **Unimax Switch Div., Maxson Electronics Corp.**, Ives Road, Wallingford, Conn.

Circle 584 on Page 19

Concealed Latch

for use on access panels

Concealed Touch Latch is designed so that light pressure at any point on an access panel will release the panel instantly; similar pressure closes the panel with positive locking action. Single hold mounting with a common nut eliminates riveting, welding, and special tooling for production-line installation. It



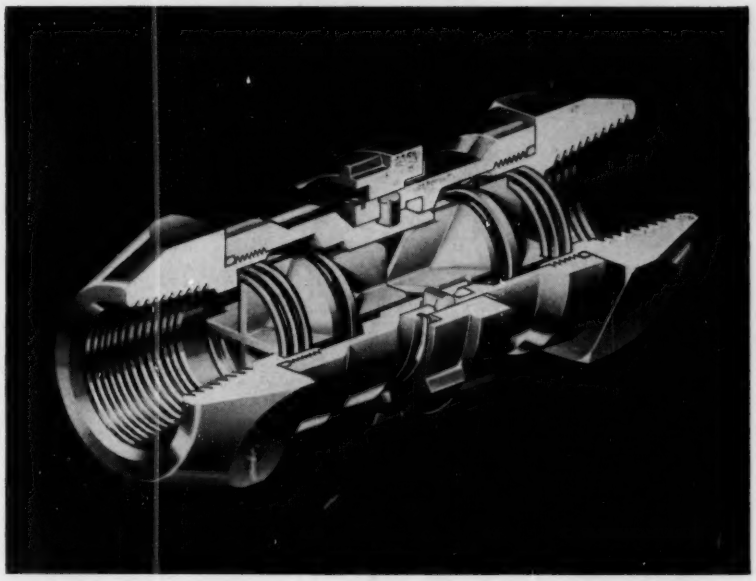
can also be mounted in castings with tapped holes. One stud design for a majority of applications has been established. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.

Circle 585 on Page 19

Ball Valve

for use at temperatures to 1000 F

Use of Graphitar seats in McCanna-seal ball valves permits their use at temperatures to 1000 F when han-



ROTO LOCK® Industrial

. . . this exceptional quick-connect coupling is now available* for industrial fluid systems handling anything from air to molasses

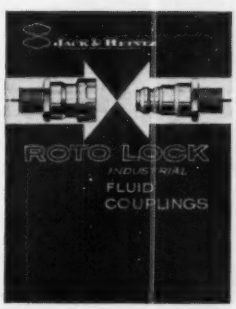
These are the performance salients of ROTO LOCK:

- **high-pressure capability**—from special locking pins that divide psi evenly over the locking mechanism
- **low pressure drop**—from "star" poppets that provide an open flow path
- **very low leakage**—from a fast-acting sealing mechanism that puts a firm, uniform squeeze on the O-rings
- **long service life**—from the maximum-contact locking pins that eliminate "brinelling" failure, common to ball-type designs
- **easy, fast operation**—one quick twist on locking collar to connect, one quick reverse twist to disconnect.

If you're looking for this type of performance, then ask for your free copy of the new ROTO LOCK Industrial Catalog, C-3001. It tells the complete design story and provides all the specifying data you'll need to fit ROTO LOCK to your exact requirements. A note on your letterhead will do the trick. Or, if you wish, just fill in the coupon below and mail.

*In standard sizes from ¼" thru 3"; no size limits on special designs.

JACK & HEINTZ
A DIVISION OF THE SIEGLER CORPORATION



Jack & Heintz
P. O. Box 6719, Cleveland 1, Ohio
Please send free copy of your Roto Lock Industrial Catalog, C-3001.

Name_____
Company_____
Address_____
City_____ Zone____ State_____

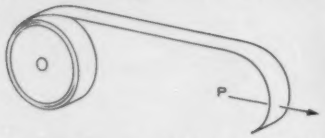
Circle 379 on Page 19

the NEG'ATOR Data Book

HUNTER Springs in Springs

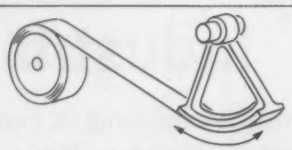
2. EXTENSION SPRINGS

Using NEG'ATOR Extension Springs to Push, Pull, Lift, and Return

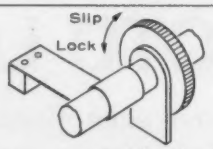


1. The NEG'ATOR spring is a strip of spring steel formed into a prestressed coil. It resists uncoiling with a uniform pull—provides a truly constant-force spring of practically unlimited length.

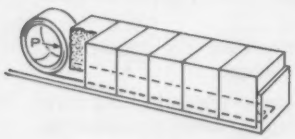
2. Used to *counterbalance*, provide *tension*, or act as a *retracting device*, it saves space and weight and eliminates cumbersome linkages. Here, two springs are used back-to-back as a counterbalance.



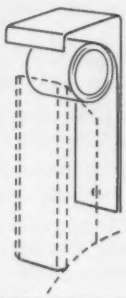
3. NEG'ATOR bands are used as oscillating *motion transmitters* to replace gears and cables. They eliminate backlash and slippage and provide smooth, quiet operation with many turns per cycle.



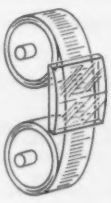
4. As a one-way clutch or brake, the NEG'ATOR prevents counter clockwise rotation of shaft as spring tends to grip more tightly. Clockwise rotation expands coil, lets shaft slip.



5. Used as a feeding device for data cards or merchandise, the NEG'ATOR spring saves space and acts over a long range. The coil pushes with unvarying force all the way.



6. The NEG'ATOR spring makes an ideal *constant-pressure* device. Used in this manner, it eliminates mechanisms for "setting-up" commutator brush springs, for example. In addition, it saves space, and cuts costs.



7. The surface of a NEG'ATOR spring can be printed and used to provide a scale of great length in a small space. Because each end tends to wrap around its bushing, the band acts as a "balanced" self-coiling scale.

How to use it?

■ Window sash balances, vending machines, compression testers, commutator brush holders, door closers, duplicating machines and countless other mechanical and electrical products employ NEG'ATOR extension springs. Write for literature.

The NEG'ATOR spring is a development of Hunter Spring Company.

HUNTER

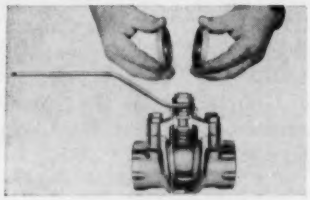
HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

3 Spring Avenue, Lansdale, Pennsylvania

DIVISIONS OF AMERICAN MACHINE AND METALS, INC.: Troy Laundry Machinery • Riehle Testing Machines • De Bothezat Fans • Tolhurst Centrifugals • Filtration Engineers • Filtration Fabrics • Niagara Filters • United States Gauge • Rahm Instruments • Lamb Electric Co. • Hunter Spring Co. • Glaser-Steers Corp.

dling nonoxidizing liquids or gases and to 700 F for oxidizing reagents. Allowable maximum pressure at the high temperatures is dependent upon the valve body materials. Succesful use of the nonresilient, high-temperature Graphitar seats is made possible by a spring which forces the ball downward into a "wedge-seat" arrangement. Resulting high mechanical advantage insures leak-tight closure. Valves are available with screwed and socket weld end



connections in 1 through 3-in. sizes, and with 150 to 300-lb ASA flanged ends in 1 through 8-in. sizes, either manually or pneumatically operated. **Hills-McCanna Co.**, 400 Maple Ave., Carpentersville, Ill.

Circle 586 on Page 19

Microminiature Capacitor

has variation of less than 10 per cent from −55 to +150 C

Microminiature 0.075-mfd capacitor is furnished in a molded case 0.56 in. square by 0.125 in. thick. Rating is 200 v dcw with a capacity variation of less than 10 per cent from −55 to +150 C. Dielectric material is barium titanate. Capacitors are supplied with either axial or radial leads. **American Components Corp.**, 15222 Grevillea St., Lawndale, Calif.

Circle 587 on Page 19

Precision Resistor

is encapsulated in hard glass

Type CG ⅛-w hermetic precision

A NEW ADDITION TO THE SONAC LINE

POSITIVE ULTRASONIC LEVEL CONTROL

The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005" and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

Canadian Representative:

KNOWLES & FOSTER (North America) Ltd.

708 Terminal Bldg., Toronto 1, Ontario, Canada

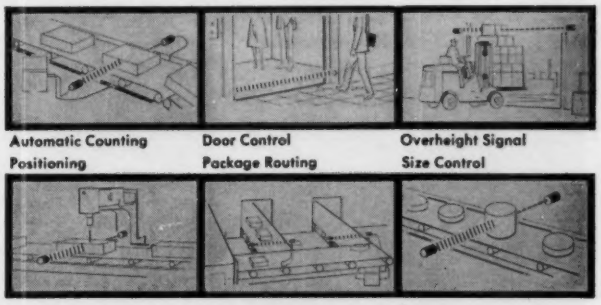
Circle 381 on Page 19

A

SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5" x 5" x 5" and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

Here's how SONAC can be used for sensing and switching applications other than level control.

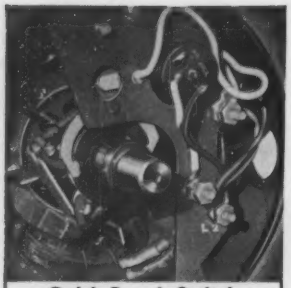


Automatic Counting Positioning | Door Control Package Routing | Overheight Signal Size Control

There are dozens of applications for SONAC *single and double sensor units. Let it go to work for you now, write:*

DELAVAN Manufacturing Company

WEST DES MOINES • IOWA



Quick Break Switch

The starting winding is disconnected from the line by this Wagner designed switch . . . test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)

Quick Connect Terminals

Brass tabs on terminal studs permit quick, easy connection of leads . . . cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.

NO STARTING PROBLEMS

with

WAGNER CAPACITOR-START MOTORS

Pack more power into less space . . . give long troublefree service . . . are easy to hook up

Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured . . . thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in . . . permits direct mounting. They are available in a range from ¼ through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings. And, sleeve bearing fhp models can be operated in any position.

Get these motors from leading distributors in your city, or from Wagner Sales Offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

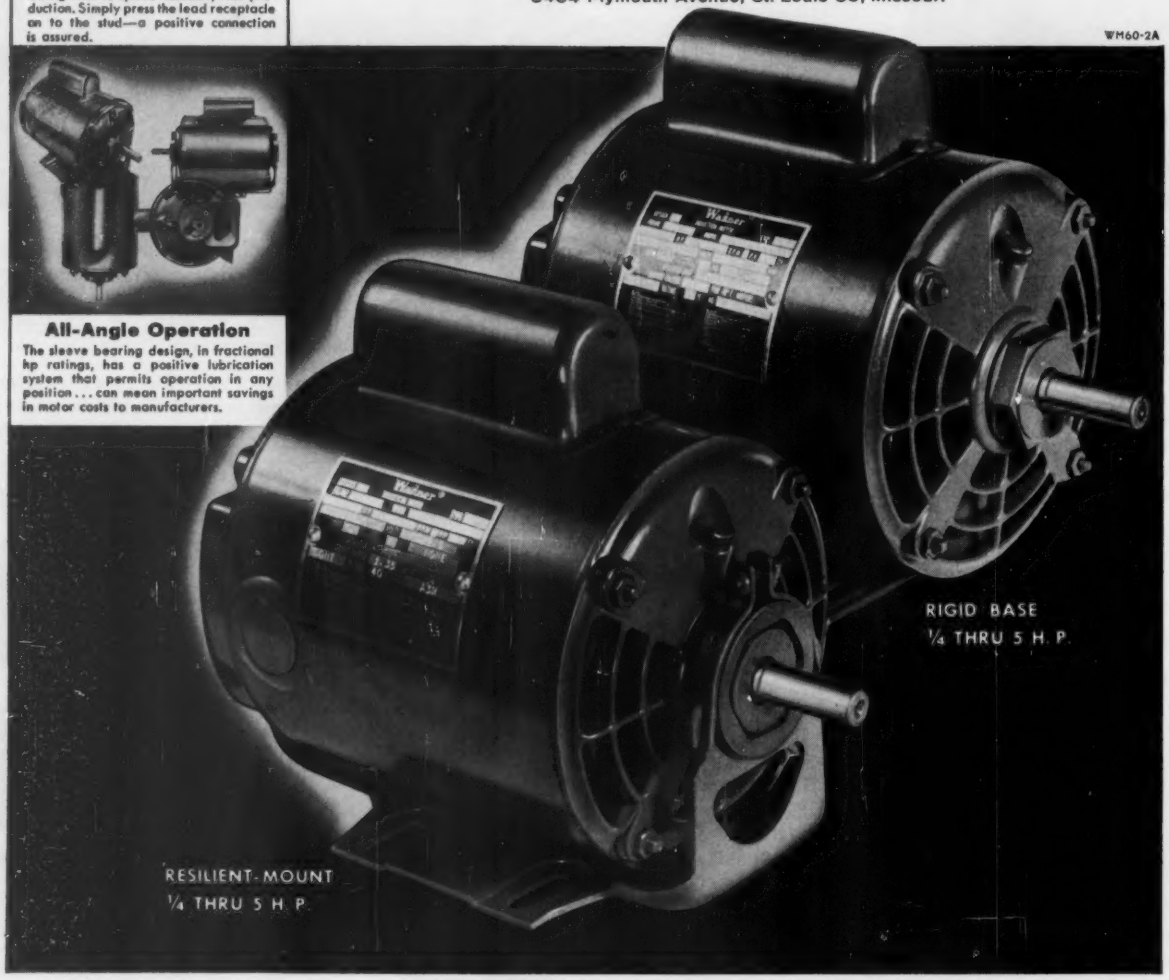
Wagner Electric Corporation

6404 Plymouth Avenue, St. Louis 33, Missouri

WM60-2A

All-Angle Operation

The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position . . . can mean important savings in motor costs to manufacturers.

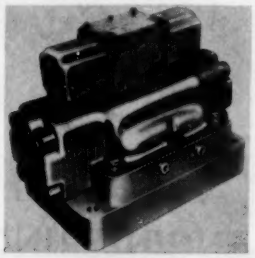


resistor encapsulated in hard glass measures only 1/4 in. long. The carbon film units (MIL Type RN55) are the same size as conventional 1/10-w film resistors. They are available in values from 10 to 100,000 ohms at a tolerance of 1 per cent. **Semiconductor Components Div., Texas Instruments Inc.**, P. O. Box 5012, Dallas 22, Tex.

Circle 588 on Page 19

Four-Way Valve

is rated at pressures to 5000 psi



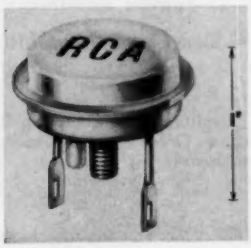
New 1½-in., four-way valve can be operated by manual, mechanical, or electrical means. It is rated at operating pressures to 5000 psi. Valve is available as a thread, subplate, or flange-connected unit. Five different spools provide for open, closed, or partially blocked flow-path connections at flows to 90 gpm. **Denison Engineering Div., American Brake Shoe Co.**, 1160 Dublin Rd., Columbus, Ohio.

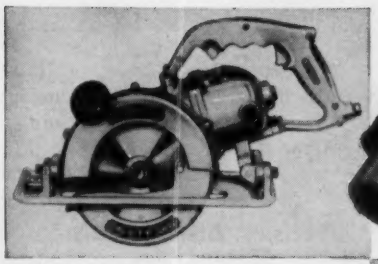
Circle 589 on Page 19

Silicon Power Transistors

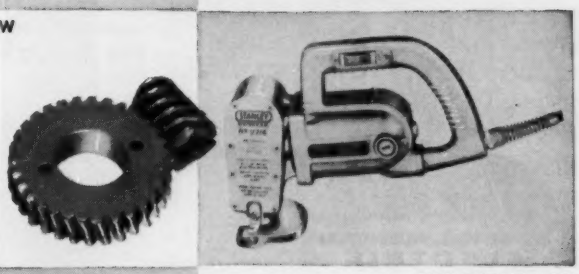
operate in temperatures to 200 C

No. 2N2015 and 2N2016 are diffused-junction, 150-w, silicon NPN power transistors for a variety of applications in military and industrial equipment. They operate at temperatures from −65 to +200 C.

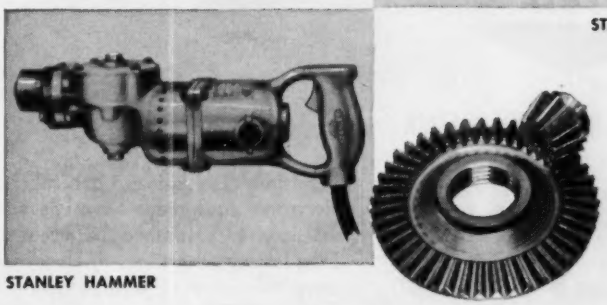




STANLEY SAFETY SAW



STANLEY UNISHEAR



STANLEY HAMMER

trouble-free, custom-cut precision gears for STANLEY

STANLEY ELECTRIC TOOLS, manufacturer of power tools, is famous for quality and dependability. They demand trouble-free gear performance.

Cutting precision gears of all types and sizes to customers' specifications is our business. As part of this, Perkins custom-gear engineers work closely with our customers' designers and production staffs. We can help you too . . . in design, improved performance, and cost control. "It makes good sense to use the help of gear experts with 52 years experience." What are your gear problems?

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

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MACHINE AND GEAR CO.

Dept. 93 West Springfield, Mass.
Telephone: REpublic 7-4751

Circle 383 on Page 19

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distance
between you
and
RELIABILITY!

LINE
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division of
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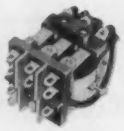
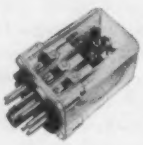
RELAYS
FOR EVERY APPLICATION
Factory Tested for Reliability!

GENERAL PURPOSE Open Type Relay. Up to 3PDT, 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.



GENERAL PURPOSE Plug-In Type Relay. Contact arrangements up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.



PRINTED CIRCUIT Open Type Relay. Up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 11.

LINE
ELECTRIC CO.
division of INDUSTRIAL TIMER CORPORATION

211 River Street, Orange, N. J.
Industrial Relays, Foot Switches, Buzzers, Coils
Phone: ORange 2-8200

Circle 384 on Page 19

Transistors are housed in JEDEC TO-36 package. **Semiconductor & Materials Div., Radio Corp. of America**, Somerville, N. J.

Circle 590 on Page 19

Precision Dials, Verniers

have tolerance of 6 min. over 360-deg range

Precision dials for mechanical and electronic equipment have engraved divisions and numbers for accurate, long-lasting marking. They also have tolerance of 6 min over the range of 360 deg, together with T.I.R. of 0.0015 between 0.375-in. hole and OD. Standard diameters range from 2 to 6 in. in ½ in. increments. Dials and verniers are available in clear aluminum and in white or black MIL Spec. paint. Graduations and numbers are filled with a contrasting color paint. **Ackerman Engravers Inc.** 43-22 36th St., Long Island City 1, N. Y.

Circle 591 on Page 19

Silicon Rectifiers

require no heat sink

New silicon rectifiers rated 1 amp continuous duty do not require heat sink. Junction is mounted on the case to effect necessary heat dissipation. Peak inverse voltage ratings range from 200 to 1000 v. Double-diffused silicon junction is hermetically sealed in new cylindrical case with all parts silver-plated for minimum contact resistance, good solderability of the leads, and thermal conductivity. Units are available with parallel leads for use in printed-circuit boards. **Electronic Devices Inc.**, 50 Webster Ave., New Rochelle, N. Y.

Circle 592 on Page 19

TIPS
AND
TECHNIQUES

VOLUME II
ENGINEERING
AIDS

- Simplifying Constructions
- Utilizing the Slide Rule
- Construction Aids
- Shortcuts for the Engineer

Helpful Tips and Techniques that apply to engineering methods, are now available in this one-volume reference. This manual contains 32 pages of illustrated time-and-money saving procedures that every engineer can use.

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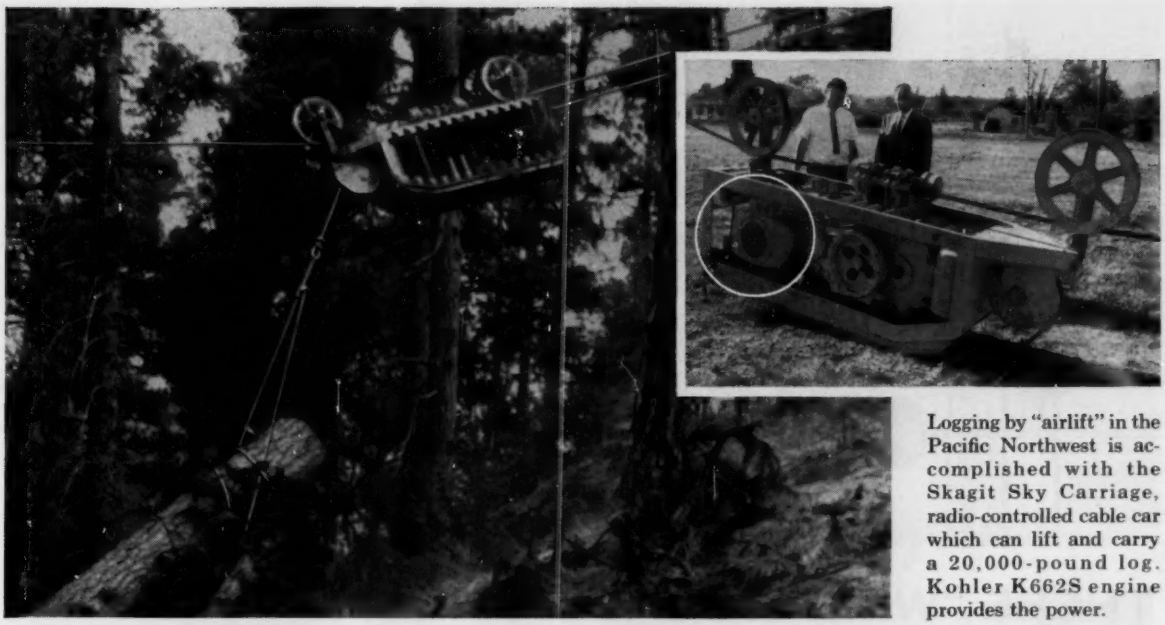
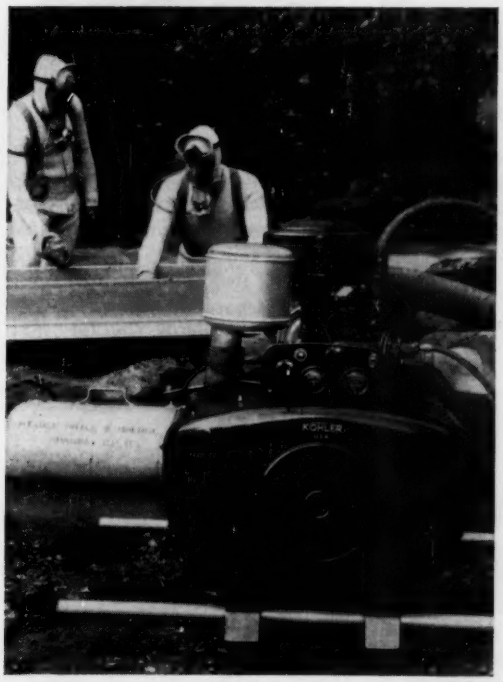


Logging by "airlift" in the Pacific Northwest is accomplished with the Skagit Sky Carriage, radio-controlled cable car which can lift and carry a 20,000-pound log. Kohler K662S engine provides the power.

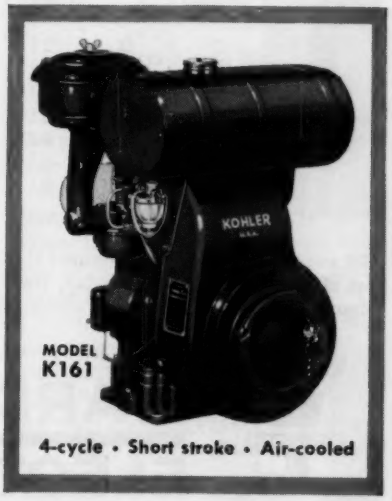
Built right for rugged duty KOHLER ENGINES



High level performance and low-cost operation by Kohler engines win confidence for new equipment from the start --and for keeps . . . They're engineered for steadfast, long-run endurance that takes rugged conditions in stride.

Strict quality control covers every step of manufacturing . . . Kohler Co. does its own iron casting . . . Large bore and short stroke design insures maximum usable power with reduced friction, prolongs engine life . . . Hot spark means fast all-weather starting . . . Balanced crankshaft cuts vibration . . . Manufactured since 1920 . . . Sold and serviced nation-wide by authorized distributors and dealers.

Gold from the river bottom is dredged by divers with the aid of a pressure pump and compressor built by Portable Pump and Dredge Co., Pomona, Cal., and powered by a K662CS Kohler engine.



4-cycle • Short stroke • Air-cooled

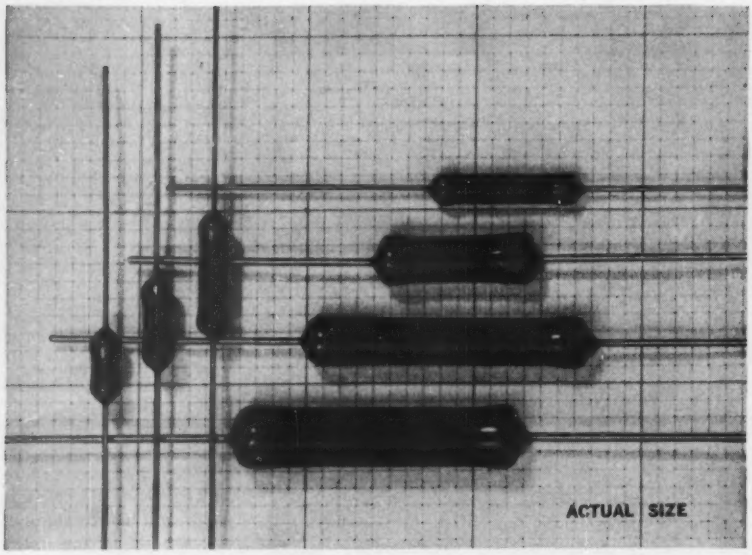
See us in Sweet's Product Design Catalog
From 4 to 24 H.P. Write for illustrated booklet.

KOHLER CO. *Established 1873* KOHLER, WIS.

KOHLER OF KOHLER

ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES • ALL-BRASS FITTINGS • ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION CONTROLS

Circle 385 on Page 19



THESE "WIRE-WOUNDS" ARE CIRCUIT SHRINKERS . . . . . *newly*

expanded line lets AXIOHM® power resistors go into smaller circuits!

Ward Leonard AXIOHM power resistors are now available in *seven* sizes—down to 2 watts, up to 12.5.

They're ideal for miniaturization in printed-circuits, industrial instrumentation and automation circuitry. But they're recommended for *any* electrical or electronic application where the highest stability and maximum overload capacity are required.

The seven AXIOHM sizes come in a complete range of resistance values (see table) from 0.1 to as high as 75,000 ohms. Naturally, they feature the qualities Ward Leonard has made famous in power resistors:

Vitrohm vitreous enamel; Ward Leonard's specially made ceramic core; specially selected and matched resistance wire; and strong, permanent, low-resistance, spot-welded, lead-to-end-cap junctions. O.9

SIZES AND RATINGS

Rating (in watts)	Type	Resistances (ohms)		Dimensions (inches)	
		Min.	Max.	Length*	Diam.
2	2X	0.1	5,000	3/8	3/16
3	3X	0.1	10,000	1/2	3/16
4	4X	0.1	15,000	11/16	3/16
5	5XM	0.1	20,000	13/16	3/16
7	7X	0.1	25,000	1	3/16
10	10XM	0.1	50,000	1 3/4	5/16
12.5	12.5X	0.1	75,000	1 3/4	3/8

*Less leads.

Get complete details in Supplement C to Catalog 15. Write for your copy and a list of stocking distributors today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

RESULT-ENGINEERED CONTROLS SINCE 1892

WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS

See us at Booth 509 at the Wescon Show

Circle 386 on Page 19

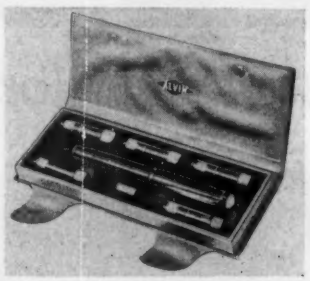
ENGINEERING DEPARTMENT

EQUIPMENT

Drawing-Pen Set

has six interchangeable drawing points

P395/C Draftech fountain-pen set is furnished with pen, rubber nib wrench, and six interchangeable drawing-point sections in line widths from superfine to extra broad. Filled directly from the ink bottle, pen supplies a large, continuous supply of



ink. Each interchangeable section has a stylus guide for smooth operation, and each nib is packed in a color-coded plastic container, imprinted with exact line width. Set is packed in a vinyl, two-button-flap carrying case with separate compartments for each unit. **Alvin & Co. Inc.**, 611 Palisado Ave., Windsor, Conn.

Circle 593 on Page 19

Magnetic-Sensing Device

for use in temperatures from −40 to +100 C

Two Hall-Effect magnetic-sensing devices—transverse-field and axial-field Hall-Paks—have uses in magnetic-field measurement and in multipliers, transducers, magnetic circuits, and other applications. Transverse-field Model BH200 is 0.500 in. long, 0.130 in. wide, and 0.019 in. thick. Active area is 0.080 by 0.180 in. Model BH 203, the axial-field unit, is 0.195 in. in diam and 3/16 in. long. Active area is 0.058 by 0.148 in. Both units are of non-inductive construction, exhibit low noise output and high Hall output,

R B & W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

by Fred E. Graves

Avoiding Bolt Failure Under Dynamic Loads

Dynamic loading in a tightened bolt may vary from no stress at all to that exceeding the bolt preload.

A classic example of dynamic loading is a connecting rod in a reciprocating engine. But you encounter such cyclic stress *wherever* you have fastened members that move or vibrate.

It has been shown that when the fluctuating stress approaches or exceeds actual bolt tension early fatigue failure can be expected.

DEMONSTRATION

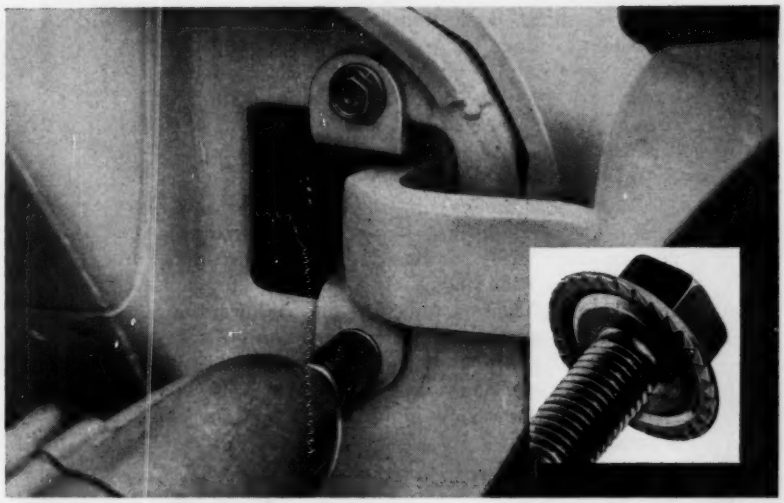
In tests, bolts tightened to a 1420 pound tension and stressed cyclically to 9215 pounds, failed after only 5960 cycles. Identical bolts tightened to 8420 pounds, and cyclically stressed to the same 9215 pounds, went 4.65 million cycles before failing.

Had the bolts been tightened to beyond the 9215 pounds, it would have been impractical to try to cycle them to failure.

So, if you want to avoid fatigue failure, be sure bolt tension exceeds the maximum dynamic load, known or estimated. This way, the bolt's life under dynamic loading will approach its life under static loading.

Take advantage of the high residual tension available to you in today's *high strength* bolts and screws, and thereby avoid fastener failures.

Why Tensilock® screws make ideal fasteners for "double-duty" jobs



TENSILOCK screws are engineered to prevent both *slippage* and *loosening*.

Heat-treated, they are so strong —even stronger in ultimate tensile strength than high-strength hex screws—that they can keep fastened members from slipping by high clamping force. As an added benefit, this permits more liberal tolerance in metalworking operations. Holes in fastened members can be oversize, slotted, eccentric, misaligned.

LOCKED-IN PLACE

Once they're tightened down, Tensilock screws can't shake or vibrate loose under reasonable service conditions. Sharp, angular, carburized teeth beneath their heads bite in to resist counter-clockwise loosening tender ·es. To back off, 25% more off-torque is required than on-torque.

SAVES PARTS, TOO

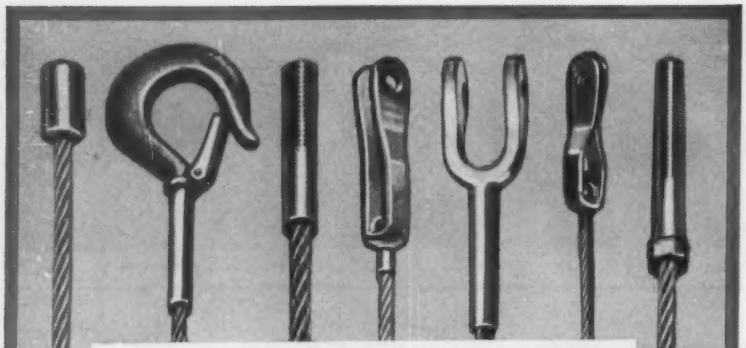
Tensilock screws combine an integral washer with their self-locking feature for a unique one-piece fastener that speeds assembly.

Moreover, with their higher clamping force, it's possible that three Tensilock screws will do the job as well, or better, than four Grade 2 fasteners.

To take advantage of them, we suggest you call in an RB&W technical advisor. Or, write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 387 on Page 19



Why bother with "home-made" wire rope assemblies?..

Cut your production costs with

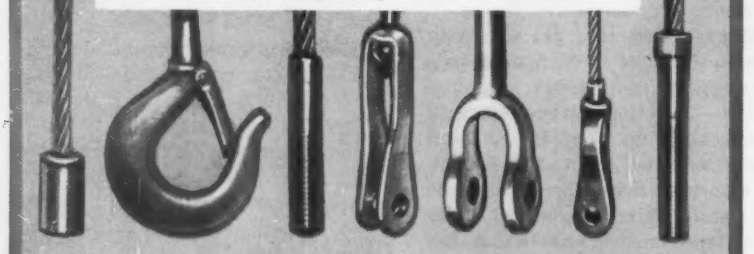
TRU-LOC ASSEMBLIES

If you are using "home-made" wire rope assemblies, consider the advantages of precision-built TRU-LOC Assemblies. With them you can be sure of consistent uniformity in length, strength, flexibility and accuracy of fittings. Swaged by the Tru-Loc process to preformed rope of 1/2" to 2" diameter, fittings develop a strength equal to that of the rope itself.

TRU-LOC Assemblies come to you complete, ready to use. They simplify installation and often cut production costs. They are neat, versatile and can be made with a wide choice of attachments to your specifications. Their per unit price may be lower than the cost of "home-made" assemblies. You get complete assemblies at a known price and eliminate variables in cost and quality. Send us a sketch of your requirements, indicating quantity, and we'll furnish a prompt quotation.

FREE REFERENCE CATALOG

This 28-page reference catalog contains photographs, engineering drawings and dimensions that provide answers to many design problems. To receive your copy, write us at Wilkes-Barre, Pennsylvania.



TRU-LOC ASSEMBLIES

ACCO

American Chain & Cable Company, Inc.

Wilkes-Barre, Pa., Atlanta, Chicago (Melrose Park), Denver, Houston, Los Angeles, New York, Odessa, Tex., Philadelphia, Pittsburgh, Portland, Ore., San Francisco, Bridgeport, Conn.

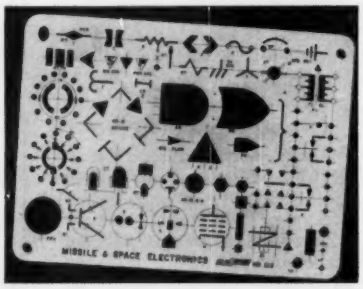
combined with low zero field output voltage to eliminate the need for external null-voltage compensation in many applications. Both units operate in temperature range of −40 to +100 C, and are designed for continuous operation at 85 C. **Semiconductor Div., F. W. Bell Inc.,** 1356 Norton Ave., Columbus 12, Ohio.

Circle 594 on Page 19

Space Electronics Template

for guidance and control-circuit drawing

Symbols on No. 316 missile and space electronics template conform to MIL-STD 70327. Template is available for the precision drawing of electronic circuits used in guidance and control of systems of military hardware in space. It is 0.030-in., matte-finish, mathematical-quality plastic. Cutouts are individually milled for accuracy and smoothness



of line. Over-all size is 7 x 5 in. **Rapidesign Inc.,** P. O. Box 429, Burbank, Calif.

Circle 595 on Page 19

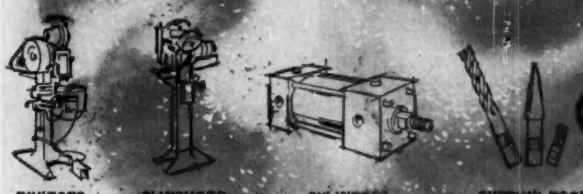
Thermocouple

has body of same material as wall of test vehicle

Model P thermocouple has been fabricated of Plexiglass, Teflon, asbestos phenolic, Micarta, graphite, copper, molybdenum, and tungsten.

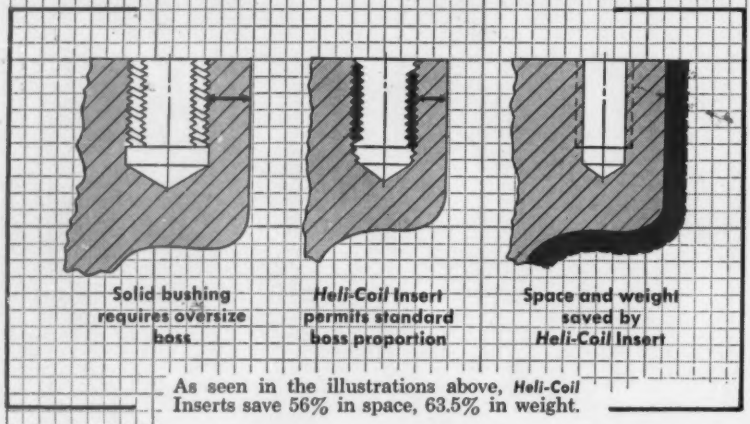
BIG NEWS

The T-J Spacemaker cylinder line is not now, nor ever has been, a probe into outer space. It is offered as a practically designed, research engineered and time tested product. Its Spacemaker feature (no tie-rods) and rugged construction gives greater strength, saves space and reduces costs in all power drive applications. The Spacemaker is available in a complete range of bore sizes and strokes, air or hydraulic, and contains many *plus features* and extras as STANDARD . . . NO EXTRA COST! Write Tomkins-Johnson, 2425 W. Michigan Ave., Jackson, Mich. for Bulletin #155-4 and for full particulars, today.



T-J TOMKINS-JOHNSON
JACKSON, MICHIGAN

How You Can Save Boss Space and Weight in Thread Design ...with HELI-COIL® Inserts


Solid bushing requires oversize boss
Heli-Coil Insert permits standard boss proportion
Space and weight saved by Heli-Coil Insert

As seen in the illustrations above, *Heli-Coil* Inserts save 56% in space, 63.5% in weight.

Heli-Coil stainless steel wire inserts have a smaller outside diameter than any solid bushing. Therefore, with ***Heli-Coil*** Inserts you can design boss radii to a minimum, yet stay with standard boss configurations. This means *savings in space and weight*, and material-savings as well.

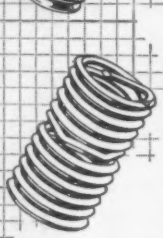
This feature is vitally important for miniaturization in aerospace design, in electrical and electronics equipment design, and for general industrial applications.

NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!

Heli-Coil Standard Insert

for stronger, smoother, lifetime threads

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration, and shock. Made of 18-8 stainless steel wire, this precision-formed ***Heli-Coil*** Insert has a tensile strength of approximately 200,000 psi. Conforms to military standards and all commercial and industrial thread forms.



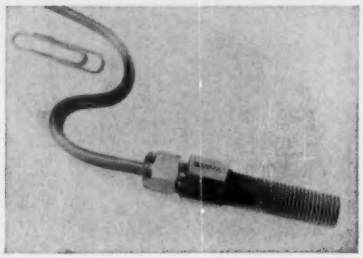
Heli-Coil Screw-Lock Insert

eliminates lock wiring and lock nuts

This one-piece wire Screw-Lock Insert provides all the thread protection of the Standard Insert, PLUS an exclusive resilient *internal* locking feature that eliminates clumsy protruding lock nuts, lock wiring and other supplementary locking devices. *It saves cost, space and weight* – permits simple streamlined design in standard bosses. Meets military and N.A.S. specifications for locking torque and vibration.

The **Heli-Coil** *line of products includes: inserts and related taps, hand tools, power inserting tools, automated tooling, and gages. Tables of boss radius and weight comparison are available. Write for complete details and design data.* 2563A

HELI-COIL CORPORATION
508 Shelter Rock Lane, Danbury, Connecticut
In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que.



Body is the same material as that of the wall of the test vehicle. Thermal elements are flat ribbon wires, insulated by thin sheets of mica. Response time is less than 10 millionths of a sec, and temperature range is −320 to over +5000 F. Unit incorporates a reusable sensing tip. **Nanmac Corp.**, Dept. 11, P. O. Box 8, Indian Head, Md.

Circle 596 on Page 19

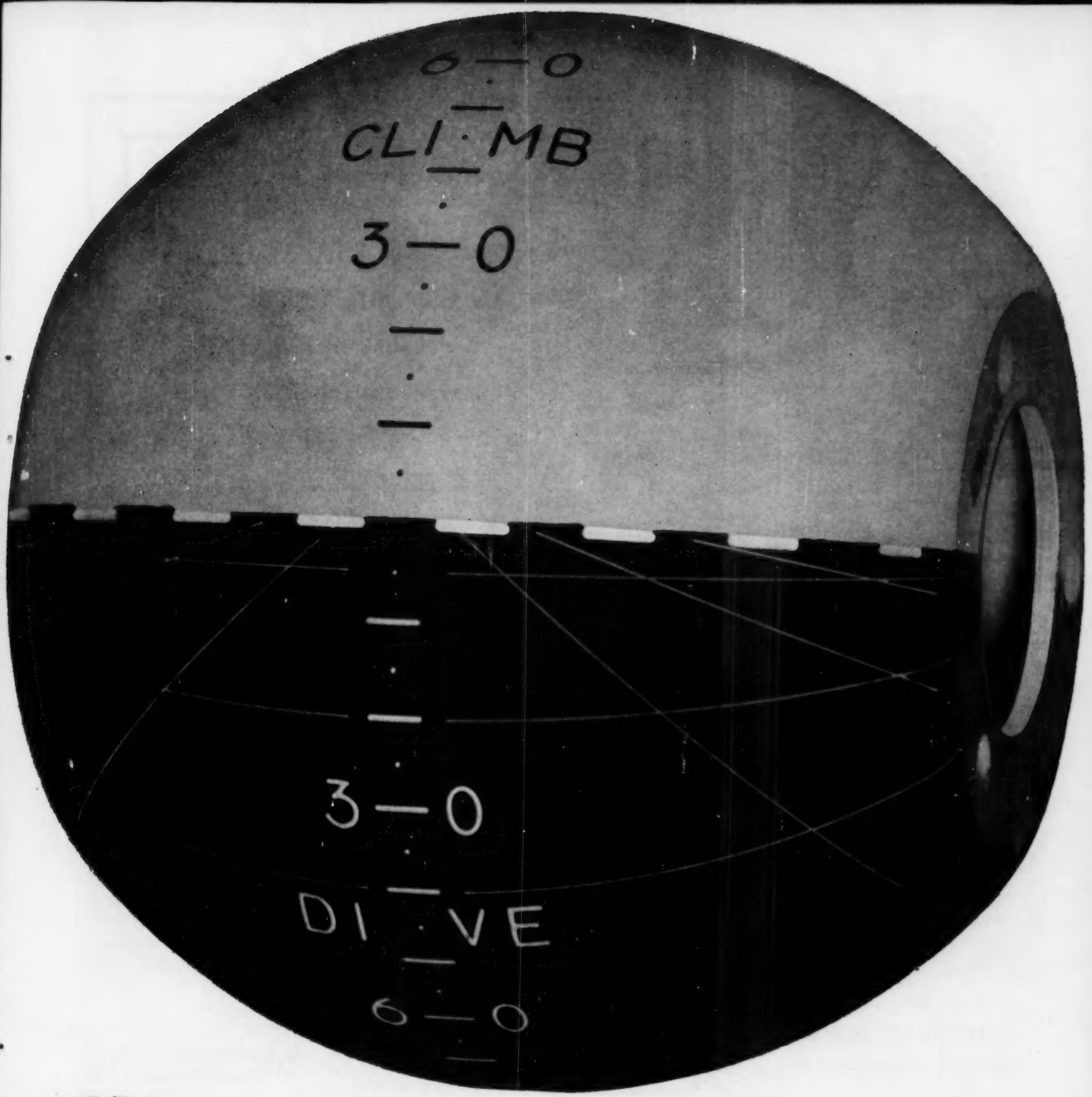
Temperature Test Chamber

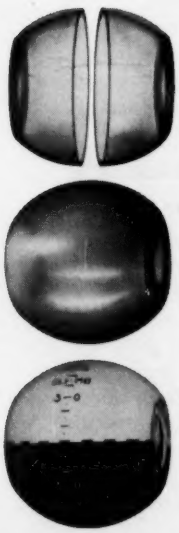
has range from −100 to +600 F

High-low temperature chamber contains a control circuit which detects very slight temperature changes within the chamber and activates a relay which provides either heating or cooling. Temperature range is −100 to +600 F. Temperature can be lowered from +70 to −100 F within 5 min and increased from +70 to +600 F in 45 min. Electric resistance-type heating unit operates on 15 amp at 115 v ac; refrigerant is liquid CO_2. Sealed construction permits continuous operation at

−100 F with no condensation forming on the insulation, and no reduction in thermal efficiency. Drawer-type chamber door locks against a silicone-rubber gasket with cam-type latches, which are easily adjustable and provide optimum seal. **Bemco Inc.**, 11631 Vanowen St., North Hollywood, Calif.

Circle 597 on Page 19





Lexan resin provides dimensional stability in close-tolerance parts

Maximum change allowable in the overall dimensions of this five-inch attitude indicator component is only 5 mils over a temperature range of –65° to 300°F! Moreover, the aircraft instrument part must maintain these tolerances under conditions of high humidity. To meet these severe requirements for dimensional stability, Lear, Inc. selected LEXAN polycarbonate resin.

In addition to high performance, LEXAN offers easy and versatile fabrication. Thermoplastic, it is injection molded in half spheres which are joined by solvent cementing. After lathe turning to insure complete accuracy, the spheres are painted three different colors. Maximum visibility is obtained by lighting from the inside. With their high temperature resistance and high impact strength, these polycarbonate spheres are both rugged and precise design elements. They are fabricated for the Instrument Division of Lear, Inc. by Monroe Industries — both of Grand Rapids, Mich.

This component is an example of what high-performance LEXAN polycarbonate resin can do for your designs. The price of the resin has gone down, too, as production has gone up. Can *you* afford to overlook the major advantages of this new, major design material? Send for design literature.

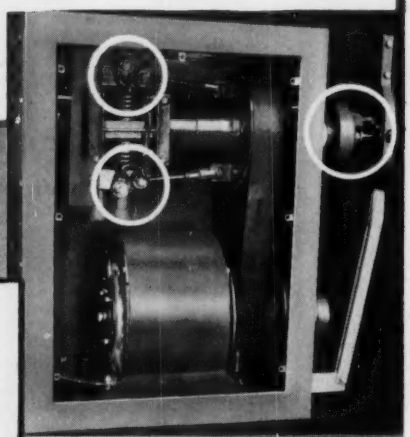
LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC
Chemical Materials Dept., Section MD-81, Pittsfield, Mass.

Circle 391 on Page 19

ORANGE SEALED

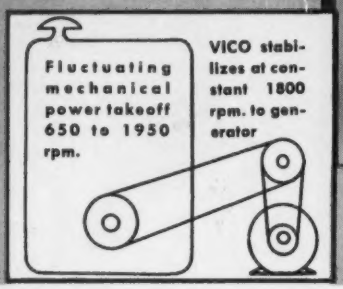
Cage Type NEEDLE BEARINGS

--simplify design
--reduce bearing space
--save production costs
for
Allmand VICO Generators



THE VICO is an ingenious generator and drive which is attached to any fluctuating mechanical power source on cranes, shovels, trucks, drill engines, etc., and converts it to electrical power with constant voltage and frequency, up to 5 KVA. Auxiliary gasoline engines for electric power are eliminated.

Ten Orange sealed cage type needle bearings are used—four double-seal bearings on each of the two governor arms and two single-seal bearings in the friction clutch. Allmand Brothers report these advantages: economy of design; bearing of small section to meet space requirements; and elimination of complex lubricating grooves in the clutch, by using single-seal bearings.



VICO Generators are manufactured by Allmand Brothers Manufacturing Co., Holdrege, Nebraska.

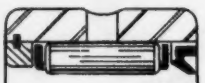
EFFECTIVE SEAL DESIGN
keeps dirt out--lubricant in

Built-in Neoprene seals provide positive exclusion of foreign matter—retain lubricant—and will relieve pressure, preventing displacement of seals when bearing is overlubricated.

- **Longer rollers for greater capacity**
- **TWO bearing lengths for flexibility**
- **Single or double seals to suit needs**

Double Seal

Only Orange construction provides effective sealing without reducing roller length or load carrying capacity. Only Orange provides two bearing lengths for each shaft diameter, with full length rollers in proper proportion to race for maximum load-carrying capacity. Orange cage design guides rollers to prevent skewing and provides exceptional lubricant capacity.



Single Seal

Orange Cage Type Needle Bearings are stocked in popular sizes from 1/2" to 2" shaft diameters. Other sizes available as volume requirements are established.

WRITE FOR ENGINEERING MANUAL M-59

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

THE ENGINEER'S

Library

Recent Books

Finite Difference Equations. *By H. Levy and F. Lessman; 278 pages, 5¼ by 8¼ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York, N. Y.; available from* MACHINE DESIGN, *$5.50 postpaid.*

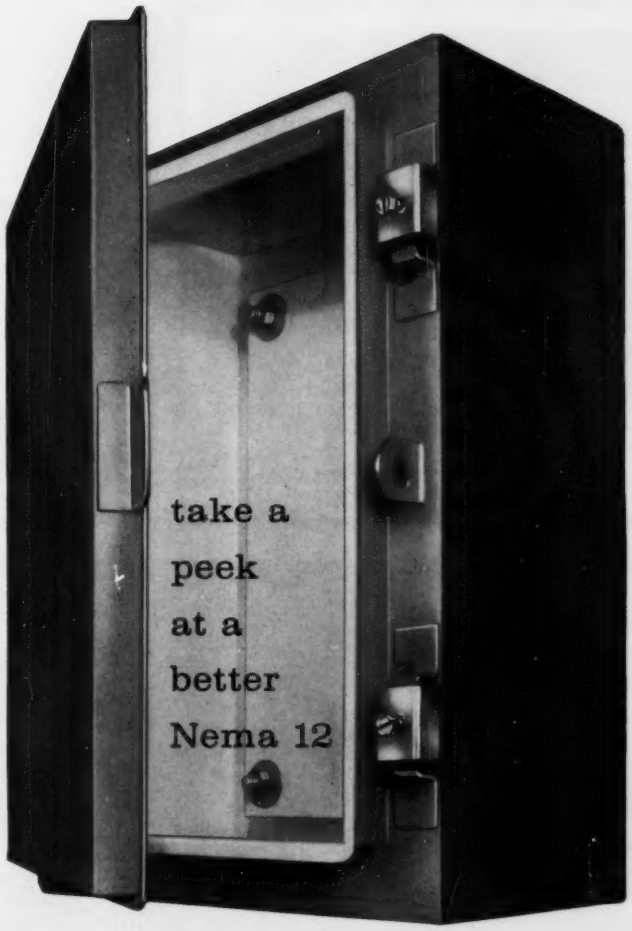
This book stresses problem solving rather than pure mathematics. Beginning with elementary difference equations, it covers interpolation and extrapolation, derivation of difference equations, solution of linear difference equations with variable and constant coefficients, and properties of the general difference equation. Other material is presented on eigenvalues that arise in connection with linear difference equations, and various modes of expansion of nonlinear difference equations.

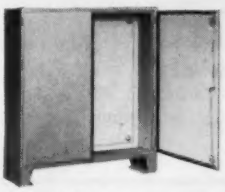
Mathematical Handbook for Scientists and Engineers. *By Granino A. Korn and Theresa M. Korn; 960 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$20.00 postpaid.*

This book provides reference material on mathematical definitions, formulas, theorems, and methods. Among the subjects covered are algebra, analytic geometry, calculus, vector analysis, integrals, Fourier analysis, Laplace transforms, differential equations, Boolean algebra, tensor analysis, probability theory, random processes, correlation functions, numerical computation, and finite-difference methods.

Compressed Air and Gas Handbook, Third Edition. *537 pages, 6 by 9 in., clothbound; published by Compressed Air and Gas Institute, 55 Public Square, Cleveland 13, Ohio; $8.00 per copy.*

This handbook provides a comprehensive reference in the field of air and gas machinery, tools and equipment. Detailed information is provided on design of compressed air systems; plant layout; design of manufacturing facilities; and in-





NEMA 12 Cabinets

JIC Pull Boxes

Pushbutton Enclosures

Open the door of a Keystone Nema 12 cabinet . . . and you'll see the unmistakable sign of quality. A positive, *liquid-tight* seal, plus durable construction and finish—make these enclosures perfect protectors for all types of electrical and electronic controls.

Keystone has a wide range of both single and double door models in stock, all built exactly to JIC and Nema specifications. Special sizes can also be quickly produced to meet unusual application requirements.

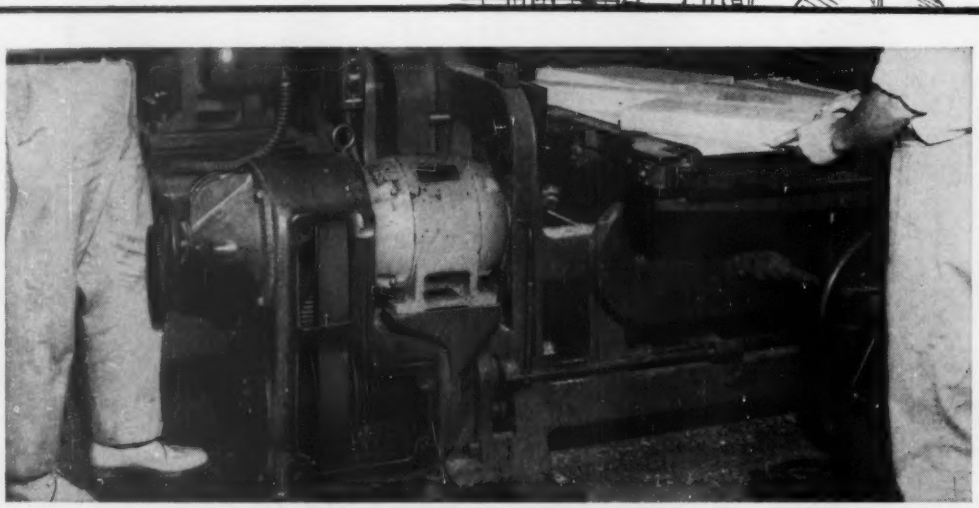
So better yet, *take a good, long look* at what Keystone has to offer in the way of Nema enclosures . . . you'll be glad you did.

Write for your new Keystone Catalog of JIC and Nema 12 Wiring Enclosures

KEYSTONE
MANUFACTURING COMPANY
DIVISION OF AVIS INDUSTRIAL CORPORATION
23332 Sherwood Ave • Warren, Michigan

Circle 393 on Page 19

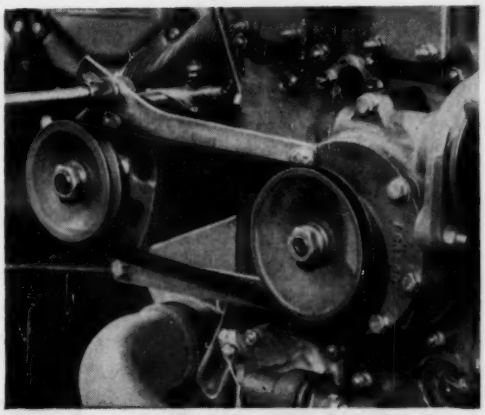
AT THE HEART OF INDUSTRY...



Making things hum for the world's largest piano manufacturer, this U.S. Royal Variable Speed Belt drives a Whitney double planer 2 shifts a day, 5 days a week at Wurlitzer's De Kalb, Illinois, plant. Installed after a competitive belt failed, this belt requires no maintenance, will last far longer, is non-squashing, non-sagging, completely reliable at speeds of 10 to 2,000 rpm.

VSB 102

Facilitating the transmission of power has long been a major contribution of U.S. Rubber...through industrial rubber products that simplify the design, improve the efficiency, and maximize the reliability of all power equipment. US has, and supplies, the products which make better power equipment possible.

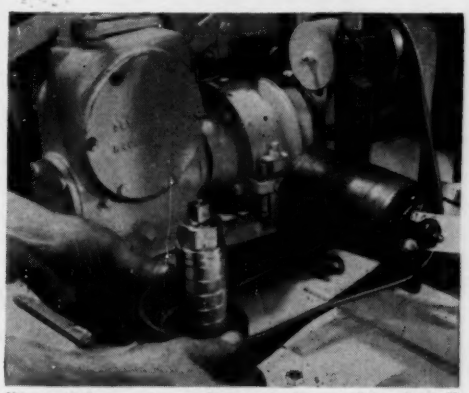


Many thousands of test hours on aircraft engines have demonstrated the remarkable efficiency and stamina of U.S. Rubber V-Belts to Continental Motors. Used to drive the generator on aircraft engines at 4,600 rpms, these belts have excellent length stability, require no maintenance, eliminate many metal parts, and render outstanding service in torque transmission.

VB 108

The revolutionary new flywheel power take-off on Reo's transit-mix truck relies on a U.S. PowerGrip "Timing" Belt for the positive, smooth, direct, and even-flowing power essential to its success. The "Timing" Belt does away with a separate engine or front-end take-off, eliminates the need for lubricants, allows a payload increase of more than 600 lbs. per trip.

TB 106



"One of the most grueling tests for a rubber belt," describes the job of US Flat Belts for Devere Rotary Power Mowers. These belts transmit power from the horizontal motor shaft to the vertical cutter shaft; perform at 3000 rpm while twisting through a 90° angle; must resist dust, dirt, oil, and gasoline. In addition, a U.S. Royal V-Belt propels the power mower.

FB 101

For every industrial rubber product need, turn to US. For Conveyor Belts, V-Belts, the original PowerGrip "Timing"® Belt, Flexible Couplings, Mountings, Fenders, Hose and Packings . . . custom-designed rubber products of every description. Discover why U.S. Rubber has become the largest developer and producer of industrial rubber products in the world. See your U.S. Rubber Distributor or contact US directly at Rockefeller Center, New York 20, N. Y.

WORLD'S LARGEST MANUFACTURER
OF INDUSTRIAL RUBBER PRODUCTS

United States Rubber
MECHANICAL GOODS DIVISION

Circle 394 on Page 19

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A symposium of six articles on the selection, specification and application of—

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- Vibrator and Dynamotor Power Supplies
- Dry Cells and Storage Batteries

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A comprehensive review of the design advances in electric motors, with special articles written by authorities in the areas of fractional and integral horsepower motors.

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stallation of compressors. Specific chapter titles include compressed air and gas in power and process service, positive-displacement compressors, dynamic-type compressors, the compressed-air plant, pneumatic tools, and general reference data.

Elementary Fluid Mechanics, Fourth Edition. *By John K. Vennard; 570 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Park Ave., South, New York 16, N. Y.; available from* MACHINE DESIGN, *$7.59 postpaid.*

This fourth edition reflects new emphases, but maintains the original organization of the previous revisions. The most significant changes are: More stress on flowfield concepts requiring use of partial derivative, deeper treatment of compressible flow and a new chapter on some elementary concepts of mathematical hydrodynamics. Material covered includes: fluid statics, kinematics of fluid motion, impulse-momentum principle, similitude and dimensional analysis, fluid flow in pipes, and liquid flow in open channels.

Management's Talent Search. *By P. W. Maloney; 164 pages, 6 by 9¼ in., clothbound; published by American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $4.50 per copy.*

This book describes how 31 executives have dealt successfully with the problem of recruiting engineers, scientists, and other professional people. It includes case studies in engineering organization at Carborundum, IBM, and Convair. Among the topics discussed are: The role of the engineering manager, recruitment and selection of engineers, compensation—both financial and nonfinancial, supervision, communication between top management, and the engineering organization.

Tensor Analysis of Electric Circuits and Machines. *By L. V. Bewley, Lehigh University; 309 pages, 6 by 9 in., clothbound; published by The Ronald Press Co., 15 East 26th St., New York 10, N. Y.; available from* MACHINE DESIGN, *$12.00 postpaid.*

This book applies the mathematical language of relatively—tensor analysis—to electric circuits and machines. This mathematical tool per-

Compact cartridge pumps provide pressure lubrication at minimum cost

by E. H. Schanzlin
Chief Engineer, Tuthill Pump Company

An opportunity for savings exists in many original equipment applications involving pressure lubrication . . . where, in many instances, foresight on the part of the designer will permit the use of a "cartridge" pump which can be built directly into the equipment . . . to provide the greatest possible capacity per cubic inch of pump . . . and ordinarily at a price below those for comparable pumps . . . since every possible extraneous element has been eliminated from their design.

14 Different Units

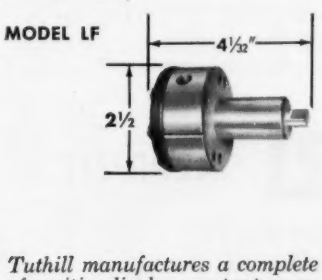
To meet the requirements of these applications Tuthill engineers have developed four different models of cartridge pumps . . . each offered in 3 or 4 sizes for a total of 14 different units . . . for pressures to 200 psi . . . with a capacity range from 56 to 720 gph depending upon pump size and motor speed. These units are all available from stock in any quantity desired. They have been used successfully in many outstanding original equipment applications.

Model LF

Model LF pumps, as shown, have an extremely simple housing and are normally furnished without seals. They are supplied in three sizes with nominal capacities as shown below.

Size	GPH	RPM
00	56	1800
0	105	1800
1	180	1800

(These nominal capacities will also apply to similar sizes of pumps discussed later.)

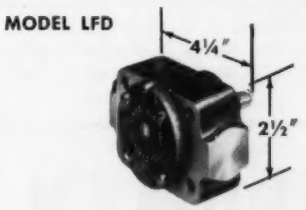


Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

Model LF pumps are designed for flange mounting. They offer a choice of internal or external porting. Overall dimensions of these compact units are only 2½" x 4½₂", and even shorter lengths are possible when pumping conditions permit.

Model LFD

Model LFD cartridge pumps are offered in the same capacity ranges and sizes as model LF. They resemble these basic pumps except that they are provided with a more detailed housing. Model LFD's are designed for flange mounting and normally supplied with either internal porting or ⅜-18 N.P.T. external porting. Shaft seals or ball bearings may also be furnished with these units as an alternate. In the 00, 0, and 1 pump sizes, these units measure 4¼" x 2½" x 3½"

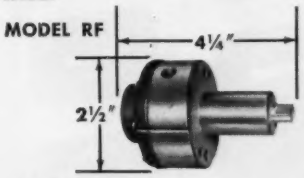


Model LFD pumps are also furnished in pump size 2, with a capacity of 360 gph at 1800 rpm, and 720 gph at 3600 rpm. Overall dimensions are 5⅝" x 3⅞" x 4¹½₂".

RF Models

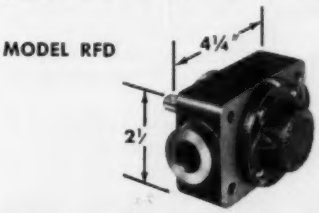
The selection of RF models closely resembles those in the LF range . . . sizes, capacities and general characteristics are identical. However, these units are equipped with Tuthill's special automatic reversing feature which permits driving the pump in either direction without changing the direction of flow . . . with port positions remaining constant . . . without special valving.

The automatic reversing design was developed by Tuthill for applications where the pump must be driven by reversing shafts, or where machinery must be shipped without knowing the ultimate direction of the driving unit. These versatile units have proven their superiority in hundreds of demanding applications.



Model RFD

These units parallel model LFD in capacities, sizes, and general characteristics. Like the model RF above, however, the pumping units have Tuthill's special automatic reversing feature for use with reversing shafts. Dimensions of 00, 0, and 1 sizes are 4¼" x 2½" x 3²⁹₃₂". Size 2 pumps measure 5⅝" x 3⅞" x 4¹½₂".



Wide Variety of Alternates

In addition to the basic pump models, various alternates can be provided. For example two alternate shaft modifications are offered for maximum adaptability.

Imaginative use of these cartridge pumps may permit significant savings in your designs. In addition to the economical price, their compactness and light weight can eliminate design headaches. These units offer the maximum amount of lubricating capacity for the minimum amount of pump . . . and often at the minimum expenditure of dollars.

For further details write for catalog section 108. Or, send details on your application so Tuthill can offer suggestions on how these units can be incorporated into your design.

PUMPS FOR YOUR PURPOSE
TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

Circle 395 on Page 19

RULON® AND TEFLON®

RULON — first practical fluorocarbon for cup packings

Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.

Dixon offers **RULON** and **TEFLON** in

- rods
- tubing
- sleeving
- sheet
- tape
- extruded shapes
- bearings
- bushings
- washers
- gaskets and packings
- bearing retainers
- machined and molded parts

RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, 100 BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

Circle 396 on Page 19

mits generalizations and unifying concepts not possible with conventional methods. Three general areas are covered: Essentials of matrix theory, mathematical theory of tensor analysis, and applications in developing equations of the generalized electric machine, with transformations to all known machines as special cases.

Russian for Scientists. *By Dennis Ward; 204 pages, 5½ by 8¼ in., clothbound; published by Macmillan Technical and Business Books, 60 Fifth Ave., New York 11, N. Y.; $3.95 per copy.*

Within the scope of nineteen lessons and four appendices, this book provides the most important rules governing parts of speech in Russian. The vocabulary included covers most of the theoretical and applied scientific disciplines. It is adaptable for independent study or for short courses in industry.

Management Guide for Maintenance Cost Reduction. *By Bernard T. Lewis and William W. Pearson; 74 pages, 5½ by 8½ in., paperbound; published by John F. Rider Inc., 116 West 14th St., New York 11, N. Y.; $1.50 per copy.*

This guide presents a pattern for application of specific principles to maintenance cost reduction. Included in the discussion are the flow process chart, tools, equipment and materials handling, principles of work simplification, and supervision and training in cost reduction.

Government Publications

TN D-813. Analysis of Partly Wrinkled Membranes. By Manuel Stein and John M. Hedgepeth, Langley Research Center; 32 pages, 8 by 10½ in., paperbound, stapled; $1.00 per copy.

A theory is derived to predict stresses and deformations of stretched membrane structural components for loads under which part of the membrane wrinkles. Rather than studying in detail the deformations in the wrinkled region, the present theory studies average displacements of the wrinkled material. Specific solutions of problems in flat and curved membranes are presented.

TN D-808. An Experimental Investigation of the Damping of Liquid Oscillations in an Oblate Spheroidal Tank with and without Baffles. By David G. Stephans, H. Wayne Leonard, and Milton A. Silveira, Langley Research Center; 23 pages, 7¾ by 10½ in., paperbound, stapled; $0.75 per copy.

An experimental investigation was conducted to determine the damping of the fundamental antisymmetric mode of oscillation of liquids contained in an oblate spheroidal tank. The decay of the fundamental mode was studied for a range of liquid depths in tanks with and without baffles. Results indicate that the addition of ring baffles to the tank provides an increase in effective damping when the baffle plane is in a region near the equilibrium liquid surface.

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency **$1.00 per copy**

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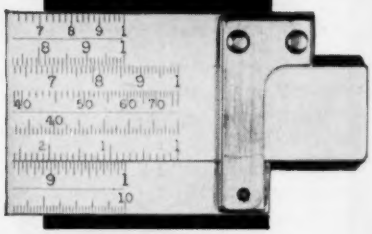
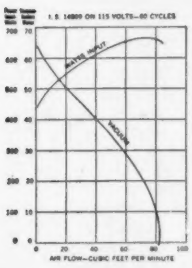


Lamb® Helps You Select The Right Vacuum Cleaner Motor

9/16 HP, 5-11/16" fan case diameter



IS-14750 thru ventilated

APPLICATION: Domestic portable cleaners.

IS-14809 by-pass ventilated

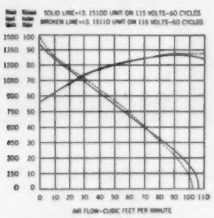
APPLICATION: Wet pick-up portable cleaners and central cleaning systems.

Service Life: Moderate
Cost: Low
Bulletins 101 & 201

NEW

1 HP, 7-3/16" fan case diameter

APPLICATION: Central vacuum systems in particular, also portable commercial wet and dry cleaners.



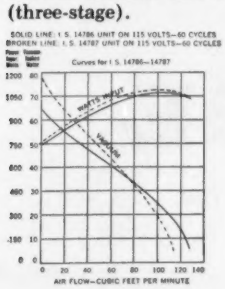
IS-15100 Diffused air discharge

IS-15110 Single air discharge

Service Life: Moderate
Cost: About twice cost of 9/16 HP
Bulletins 251 & 252

7/8 HP, 7-1/2" fan case diameter

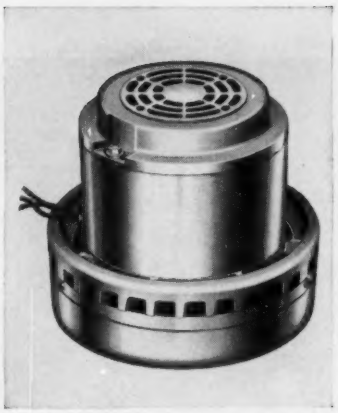
APPLICATION: Portable Heavy Duty Commercial Cleaners and Central Systems (three-stage).



IS-14786 2-Stage

IS-14787 3-Stage

Service Life: Long
Cost: About 3 times cost of 9/16 HP
Bulletin 301



IS-15100 (Diffuser Discharge)

IS-15110 (Single Air Discharge)

Special Requirements of Central Vacuum Systems Met by New High Performance Motor

Existing vacuum motors have been designed to perform best when incorporated into portable vacuum cleaners of standard types and sizes. Such motors are built to produce highest efficiency under air flow conditions that exist in normal domestic and industrial cleaning service and where hoses are of normal length and diameter.

On special applications, like central vacuum cleaning systems that utilize extremely long cleaning hoses, and where tubing losses are present, a special motor is required. To meet this need, Lamb now offers a vacuum motor which will maintain a relatively high vacuum with a modest amount of air flow. The result: these motors operate at high efficiency in the high vacuum range without sacrificing air flow performance under low vacuum conditions.

INPUT – 10 AMPERES at 115 VOLTS

For economical, cleaner design, this rating at Underwriters' test point was selected as the input limit. This allows use of line cord not exceeding number 16 type SJ and control switches of 10 ampere rating.

NEW TAPERED BLADE DESIGN

On central systems which employ centrifugal dirt separation, a small amount of fine dirt and lint must pass through the fan and is discharged outside of the building. For maximum efficiency, this type of fan blade is designed with a long backward curving sweep which, however, may accumulate fine dirt due to centrifugal action. This dirt builds up to a point where starting acceleration dislodges dirt from one blade, resulting in unbalance, noise, and vibration. Special steep angle blades have been used but they also have serious performance limitations.

Lamb research has developed a moderately steep blade angle plus a tapered form. The result is a compromise that yields excellent performance and all but eliminates the dirt loading problem.

CHOICE OF AIR DISCHARGE SYSTEMS

Lint accumulation is minimized and high vacuum is improved in the IS-15110 with a single tangential discharge pipe. This allows for easy connection to a discharge piping system, if desired.

The IS-15100, by discharging air through slots in the fan case, results in better noise suppression.

FAN-END BEARING IS PROTECTED BY AIR COOLING

Motors in central vacuum systems are often required to operate for long periods of time under sealed conditions – which results in a high temperature rise in the fan system. In ordinary by-pass type motors, the electrical parts have a separate cooling system, but bearings in the adjacent fan case often become hot enough to destroy the lubricant. Early failures can and do result. Lamb's new motor prevents this by providing a unique ventilating system which directs cooling air over the fan-end bearing and protects the motor from harmful heat built-up within the fan case. For complete details, write to Lamb Electric Company, Kent, Ohio – ask for bulletins shown at left. *Also available – explosion-proof model. Ask for bulletin 401.*

Circle 397 on Page 19

SAVE SPACE, SAVE WEIGHT, SAVE MONEY!

Dyna V

There's a *difference*, as you can see! The 10-groove D-section sheave in the foreground is replaced with the narrow 8-groove 5-V Dyna-V sheave on the line shaft. *Same power*, in a far more compact installation, with a $477 difference in price. And big future savings in belt replacement costs!

Everyone is going Dyna-V! Thousands of installations reveal that Dyna-V performance is *even better* than promised when we first introduced this new compact drive. In medium and high horsepower ranges, savings go as high as 30%!

Dyna-V can handle 3 times as much power in the same space. Dyna-V Sheaves decrease shaft overhang, increase bearing life. And Dyna-V Belts possess *all* premium qualities. Conditions requiring static conductivity or resistance to oil, moisture and heat are met by Dyna-V's one grade—the finest. Ask your Dodge Distributor, or write us for complete drive bulletin. Dyna-V Drives are available for capacities from 1 to 1500 hp.

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Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66-MD.

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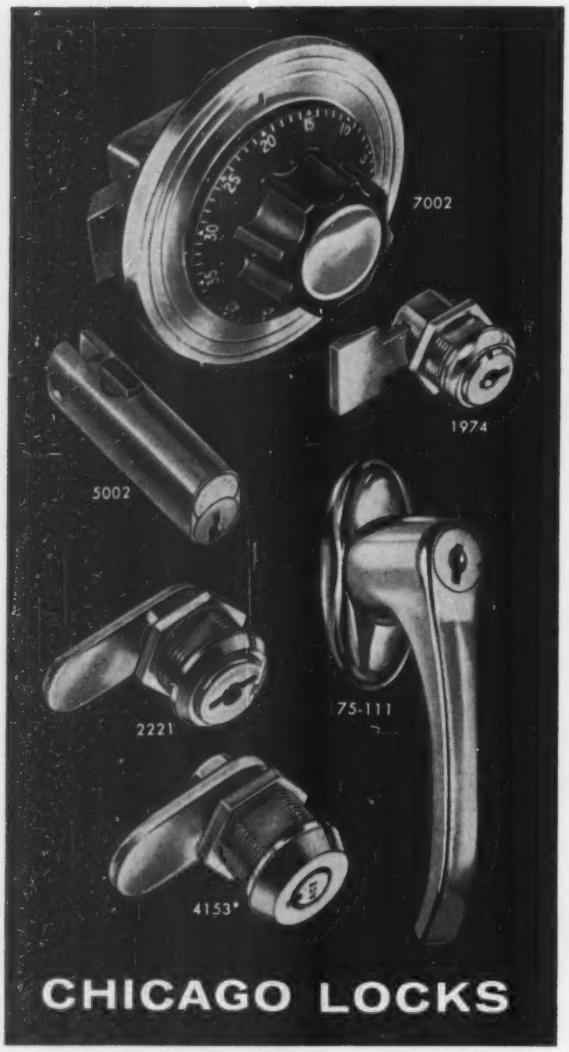
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric



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Whatever your needs, you're sure to find a Chicago Lock that's perfect for your purpose . . . *and priced right, too.*

*One of the ACE Lock line—Maximum security locks with the exclusive round keyway.

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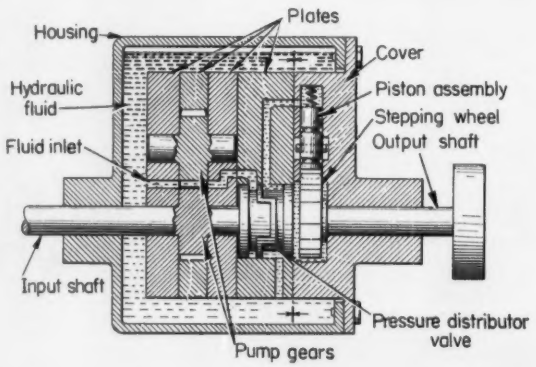
NOTEWORTHY

Patents

Hydraulic Stepping Motor

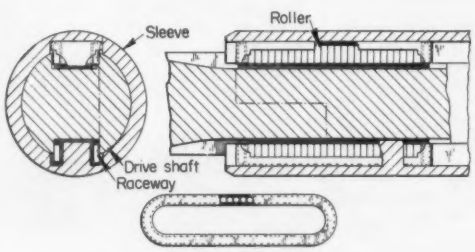
A hydraulic stepping motor converts a constant rotary input motion into an intermittent incremental rotary output motion. Motor comprises a number of drive pistons which are successively energized to engage a toothed stepping wheel on the output shaft. The driving force applied to the pistons causes the pistons not only to advance the stepping wheel but also to detent the



wheel for a predetermined period of time, providing intermittent motion. The size of pressure supply and exhaust ports can be adjusted with throttling valves so the build-up of pressure in the cylinders can be varied. This action varies the dwell period for each increment of advance. *Patent* 2,987,889 *assigned to International Business Machines Corp., New York, N. Y., by Daniel P. Darwin.*

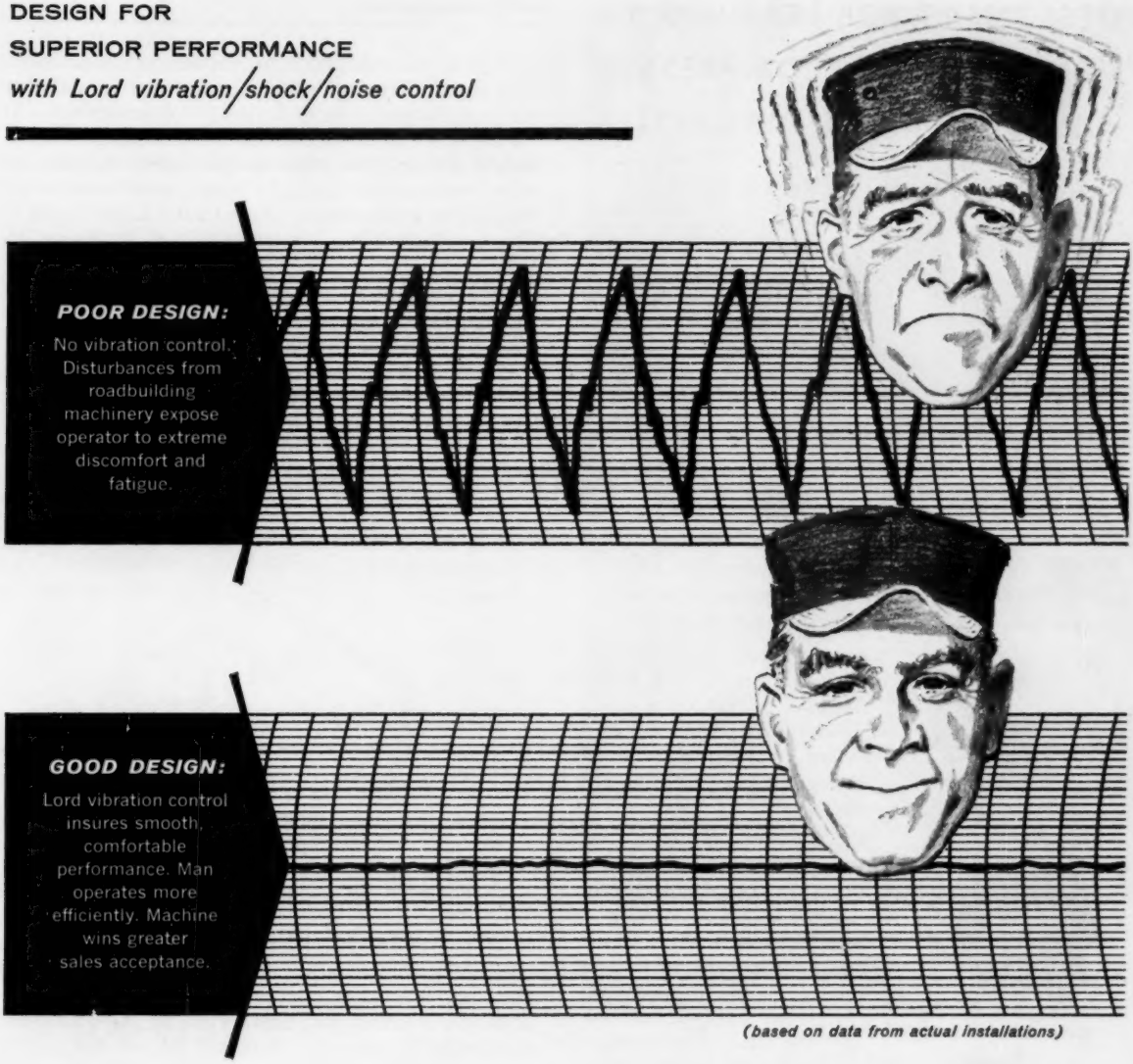
Roller-Bearing Spline

A small-diameter roller-bearing assembly permits low-friction longitudinal movement through rolling contact between two members. The assembly is used in a drive



shaft where the spline is modified to receive two or more of these bearings, and the driven part must move longitudinally with respect to the driving part. Bearing consists of a number of rollers spaced along a raceway;

DESIGN FOR
SUPERIOR PERFORMANCE
with Lord vibration/shock/noise control


POOR DESIGN:
No vibration control. Disturbances from roadbuilding machinery expose operator to extreme discomfort and fatigue.
GOOD DESIGN:
Lord vibration control insures smooth, comfortable performance. Man operates more efficiently. Machine wins greater sales acceptance.

(based on data from actual installations)

is your product designed for humans?

Operator comfort is an increasingly vital aspect of good design.

Users of your products—truck drivers, farmers, heavy equipment operators—prefer and *today expect to get* smooth-performing equipment. Objectionable noise and vibration can be costly—returned equipment, lost sales, damaged prestige.

Today's products must be designed for humans . . . and this is where Lord can help. High-strength elastomeric mountings and joints can be custom designed to isolate the operator from dynamic disturbances. Gone will be the jarring, rattle and roughness that are dead giveaways of poor design.

Instead you will have a vehicle that rides better, sells easier and stays sold.

Remember this: product designs that start with Lord vibration/shock/noise control end up with a competitive edge. See our product guide in Sweet's Design File. Better yet, contact the nearest Lord Field Engineering Office listed here or the Home Office, Erie, Pa.

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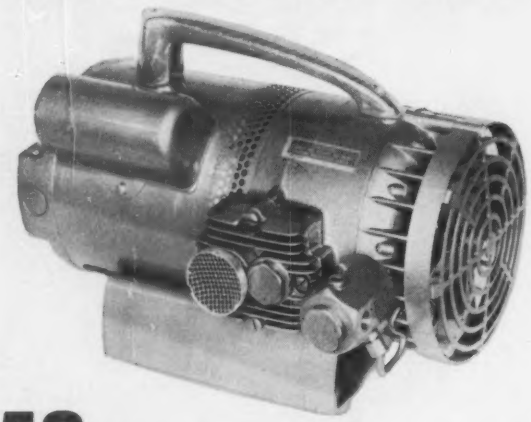
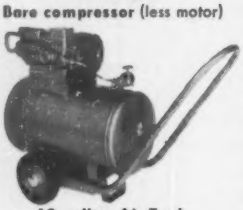
DESIGNERS ARE LEANING TO B&G® *Oil-less* COMPRESSED AIR TO DO MORE JOBS BETTER

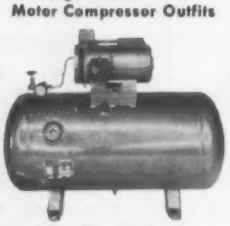


58 MODELS—1/12 to ¾ HP—Pressures: to 190 psi. Vacuum: 27.5"—Air displacement: to 6.57 CFM.

Bare compressor (less motor)



10 gallon Air Tank Motor Compressor Outfits



30 gallon Air Tank Motor Compressor Outfits

Gasoline Engine Driven Compressor Outfits

Use of compressed air is rapidly increasing because of its many exclusive advantages as motive power, for process agitation and for energizing intricate mechanical movements. B&G Air Compressors fit ideally into this picture because they are *oil-less!*

There is no chance of oil-spoiled work—*not a drop of oil* can be found in this compact, lightweight compressor. Motor and compressor are permanently grease-packed...carbon-graphite piston rings and skirts operate for years without injury to the cylinder walls. Since the cylinders are not oil lubricated, air is always oil-free—no oil separator needed—no costly lubrication maintenance.

B&G oil-less Compressors are velvet-smooth! Modern design, large bores, short stroke, horizontally opposed pistons provide better balance and vibrationless operation. B&G Compressors are available in a complete line of portable, tank mounted, tankless and gasoline engine driven models.

Send for Catalog GO-259

Oil-less AIR COMPRESSORS

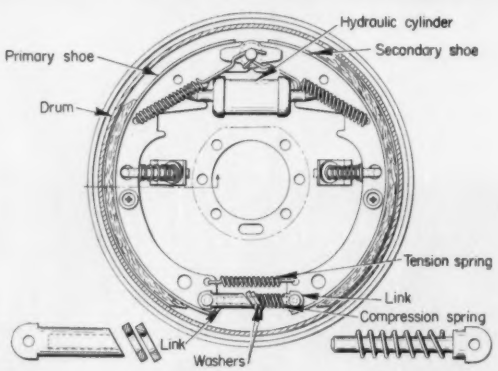
BELL & GOSSETT COMPANY

Dept. GT-67, Morton Grove, Illinois

extending perpendicular from the raceway is a flange. This flange forms part of the roller retainer by confining one end of the roller to limited axial movement. At the opposite end of the raceway is an extended channel-shaped flange. The ends of this flange overlap the roller bodies, thus forming a closed guide and return channel for recirculation. *Patent* 2,981,750 *assigned to The Torrington Co., Torrington, Conn., by Robert H. White.*

Self-Adjusting Brake

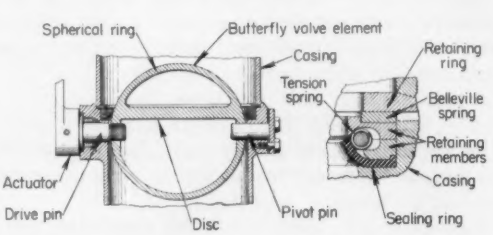
Excessive clearance between brake shoes and drum is automatically adjusted during brake operation by three spring-loaded struts. Two of the struts are connected to the central web portions of the brake shoes and one is connected at the shoe ends. All three struts operate in a similar manner. The lower strut comprises two



links, one of which carries a spring and two washers. The action of the spring and the bevel-shaped end of the outer (sleeve) link causes the strut to become automatically extended and then locked by the washers as the brake is operated. *Patent* 2,981,379 *assigned to General Motors Corp., Detroit, Mich., by Frank C. Burrell.*

Low-Temperature Butterfly Valve

A spherical ring on a butterfly valve engages a sealing ring when the valve is in the open position to provide for low-temperature operation. The valve disc itself

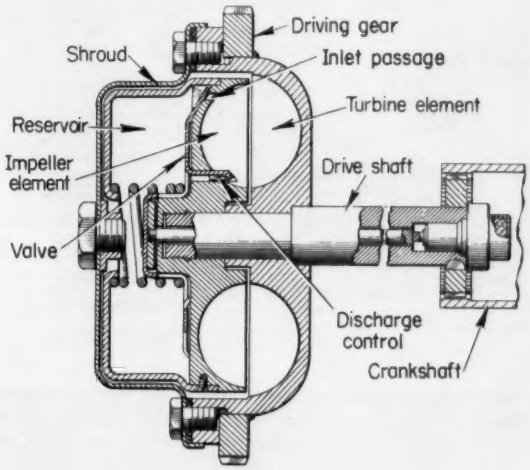


engages the same sealing ring when the valve is closed. Thus, with the valve in either its open or closed position, initial contact of low-temperature fluid against the seal ring causes it to contract against the periphery of either

the valve disc or spherical ring. This arrangement prevents warping of the ring into an out-of-round condition. The ring is fitted with a tension spring to provide pressure-tight contact with either valve element. *Patent 2,988,320 assigned to Clary Corp., San Gabriel, Calif., by Preben Kent.*

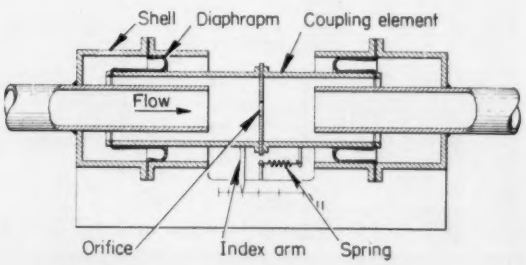
Adjustable-Speed Fluid Coupling

In a drive coupling, fluid flow is automatically controlled into and out of the working circuit to obtain close speed regulation. By varying the quantity of fluid the speed ratio of the coupling may be altered. For instance, when the coupling is completely filled, the torque capacity is maximum and the output member is driven at maximum speed. As the coupling is emptied, torque capacity and speed progressively decrease. Fluid flow is controlled by a valve located between the reservoir and inlet and outlet passages. Valve operation, in turn, is controlled by a thermosensitive device. *Patent 2,987,887 assigned to General Motors Corp., Detroit, Mich., by F. Robert J. Fowler.*



Moveable-Orifice Flow Meter

Inlet and outlet tubes in a flow meter are spaced apart in a movable coupling that positions a pointer along a fixed scale. Each coupling end is connected to the surrounding shell wall by a flexible, nonmetallic diaphragm of U-shape cross-section. The coupling it-



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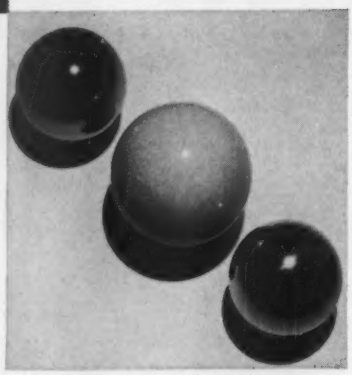

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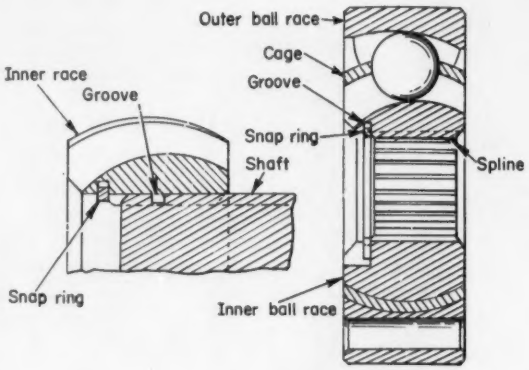
self contains a transverse disc having a small orifice. As the fluid pressure in the inlet tube increases relative to the outlet tube, the coupling and attached pointer move to the right and flow may be read directly from the fixed scale provided. *Patent* 2,987,915 *assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., by August J. Hildenbrandt.*

Quick-Release Universal Joint

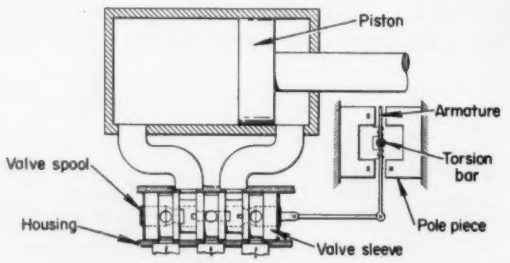
In a universal joint, a splined inner ball race is locked to a mating splined shaft by a snap ring. A pair of recesses are provided on opposite sides of one of the openings in the inner ball race. These openings expose the



extended end portions of the snap ring for easy access. Thus, the ball race and shaft may be readily disconnected without the use of special tools. *Patent* 2,987,897 *assigned to Dana Corp., Toledo, Ohio, by Robert E. Spence.*

Compensated Flow-Control Valve

A control valve automatically compensates for unsymmetrical flow rates, pressure drops, and momentum forces. Valve consists of two parts: An electromagnetic driver and a metering element. Metering element regulates the fluid output by controlling orifices within the supply and return ports. In operation, the widths of



these orifices are determined by the stroke of the valve spool. However, to compensate for unequal flow rates because of the unidirectional load and the large piston rod, the lengths of the orifices are different. Static balance of the valve spool is achieved under no-flow

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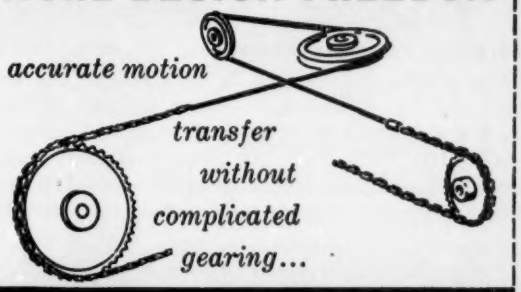

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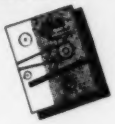

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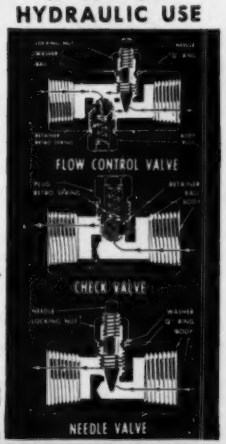
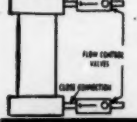
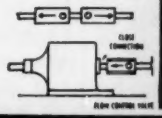


Inlet speed control for Double Acting Cylinder.



Single Acting Cylinder Speed Control.



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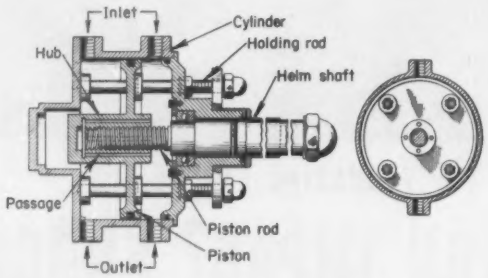
conditions by exposing the spool lands to the supply pressure fluid. *Patent 2,987,050 assigned to Sperry Rand Corp., by Ernest Oppenheimer and Frank Seiden.*

Remote Hydraulic Drive Unit

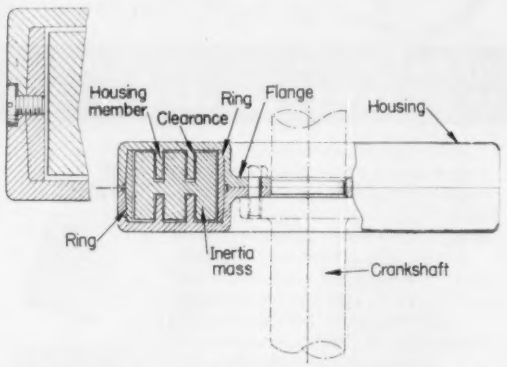
A master hydraulic drive unit, coupled through a two pipe system, remotely controls the motion of a driven unit such as a rudder, camera boom, or fire fighting turret. Unit comprises a cylinder, double acting piston, and a threaded piston rod. The piston



rod is extended to serve as a control shaft. Movement of a wheel attached to the shaft causes rotation of the piston rod, imparting a corresponding linear movement to the piston. This action displaces hydraulic fluid in the cylinder through the pipe system to the driven unit. System is completely balanced because the volumetric displacement remains constant throughout the piston stroke. *Patent 2,987,888 assigned to Crowell Designs Inc., by Gordon W. Crowell.*

Torsional Vibration Damper

An annular inertia mass is housed within a fluid chamber to damp torsional vibrations of rotary members such as crankshafts. The fluid chamber contains a viscous fluid such as silicone. This fluid offers a shear resistance to the damping mass and resists relative motion between the mass and internal walls of the housing.



Housing is made of split halves and joined together to form a closed fluid chamber. Two rings, located at each end of the chamber provide a fluidtight connection without the use of packings or welded seams. *Patent 2,987,938 assigned to General Motors Corp., Detroit, Mich., by Lewis D. Burch.*

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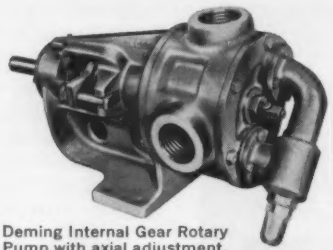

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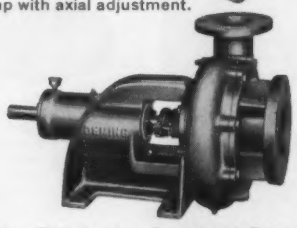

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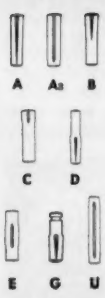

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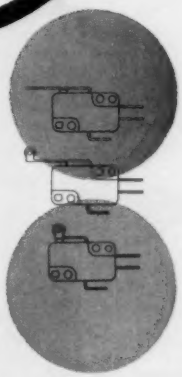

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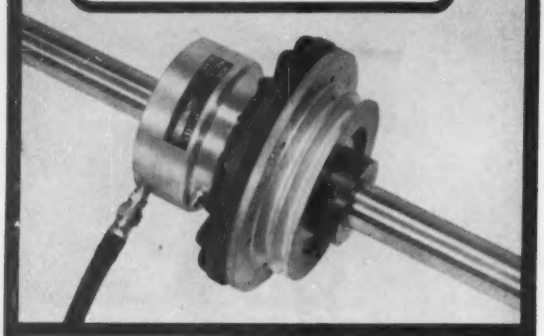

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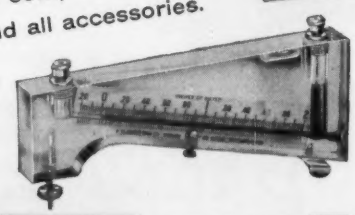

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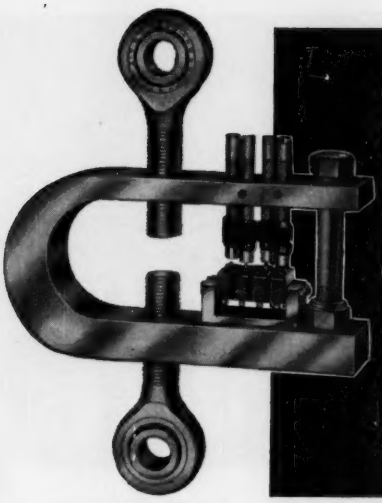

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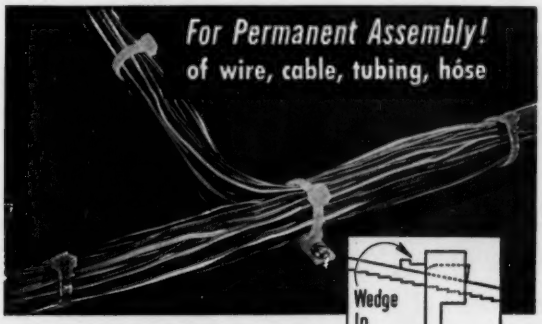

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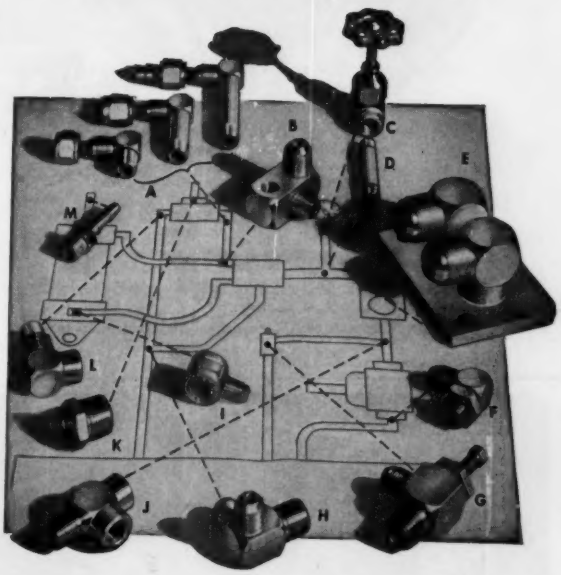

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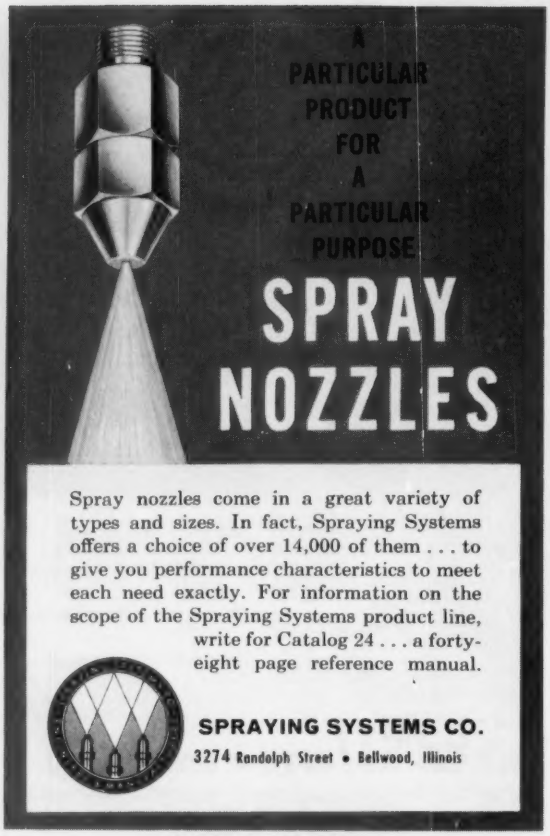

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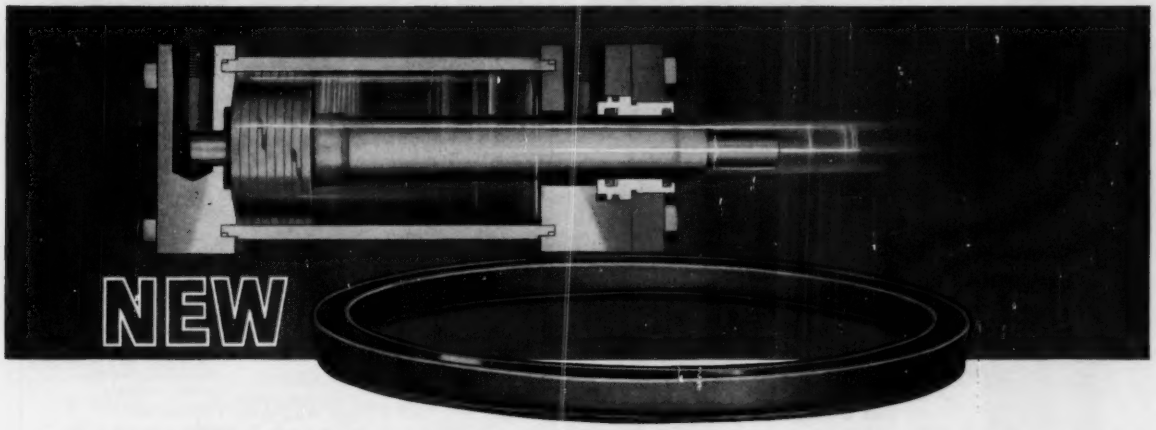

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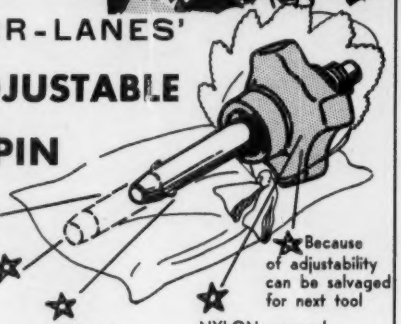

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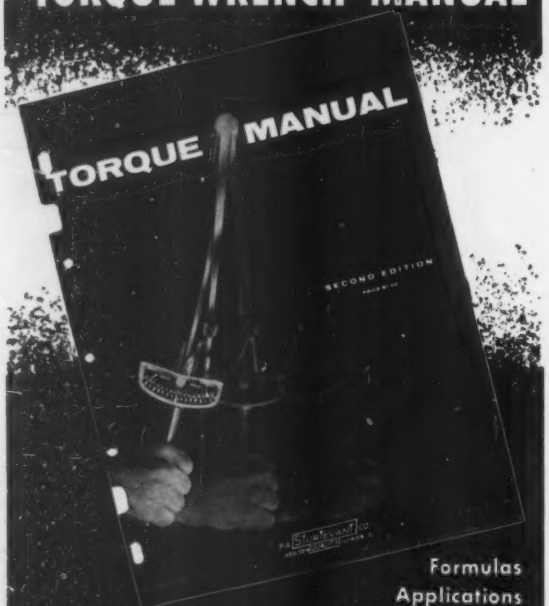

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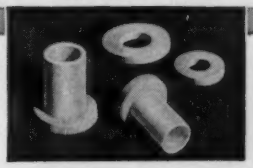

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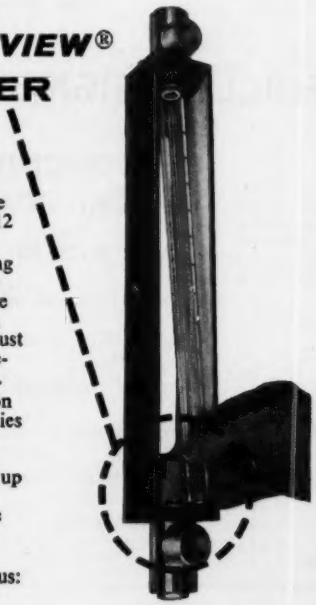

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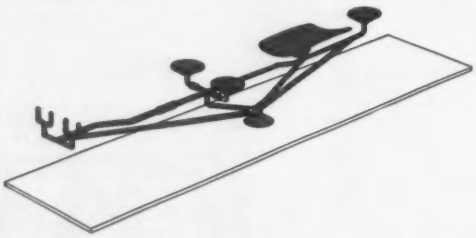
backtalk——

—And So to ?

A reader tells us that he was somewhat amused at the chair illustrated on our Industrial Design page for July 20. (Remember the thing with an aluminum frame and three rubber discs located to support seat bones and back?) Mr. Nova B. Kiergan III of the U. S. Naval Avionics Facility in Indianapolis, although "fairly skeptical" of the chair's comfort, sat down (on a soft cushion, no doubt) and designed a companion piece.



This is a bed, which Mr. Kiergan claims is "just as modern and even more uncomfortable than the chair."

—Footnote on Headlining

Some of our News article titles are developed by the brainstorming technique, and such a session was held for the article on dangers of radiation to astronauts (Page 24). Of all the rejected titles, we still like "Go Now, Pay Later."

—Foil Foils Fowls

Philadelphians apparently feel no more affection for ill-mannered birds than do inhabitants of other cities. There, however, at least two people are doing something about it. Charles and Samuel Cohn, who own Colonial Alloys Co., kept birds off their roof by attaching a narrow strip of serrated aluminum foil to the edge. A bird will land only on a roof's edge, never on the flat part. And, if the edge won't hold him, he flies away.

Charles Cohn has also patented an idea for saving utility poles from woodpeckers. Again, serrated aluminum foil is used, fastened in vertical strips to keep the birds from getting a firm pecking grip.

Neither of these repellers harms or frightens the birds. After all, this is Philadelphia.

—If I Knew You Were Coming . . .

Because of our high regard for the distaff side of the engineering profession, we're sure it's O.K. to have been amused by this story. During the annual meeting of the Society of Women Engineers, attendees visited the Missile & Space Div. of Raytheon Co. in Bedford, Mass. They were shown a movie on missiles and heard a talk by Martin Schilling, Raytheon's vice president of engineering and research. Refreshments were also on the agenda, and the ladies had beverages, ice cream, and cakes—which they baked themselves.

Actually, this was not just a way of helping the girls keep a hand in domestic affairs while furthering their careers. The baking was done in Raytheon's radar range, a device which would have intrigued the other kind of engineer as well.

—Squeeze Play

In this year of aluminum's seventy-fifth anniversary, the Aluminum Association has established two awards for the design of extrusions. The competition is sponsored by the association's Aluminum Extruded Products Div. Extrusions designed, produced, or converted into a finished part may be entered in one of two categories: 1. Most Ingenious Extrusion. 2. Most Ingenious Part Made from an Extrusion. U. S. extruders may nominate their own or customers' designers for awards. Trophies will be given to the individual associated with each of the two winning entries. Companion trophies will go to producers of the extrusions and, under certain conditions, to the die shops. Entry forms can be obtained from Awards Committee, Aluminum Association, 420 Lexington Ave., New York 17, N. Y.

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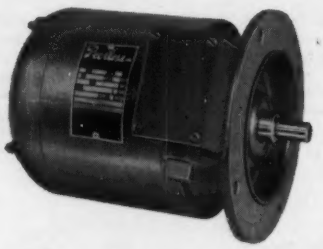
if you use TORQUE MOTORS

. . . the name is *Peerless*

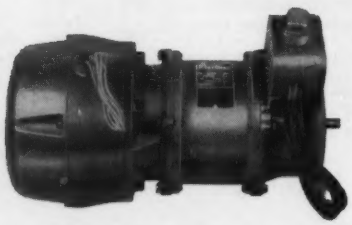
The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 oz. in. to 200 lb. ft.

Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.



Weather-Tight Special Flange



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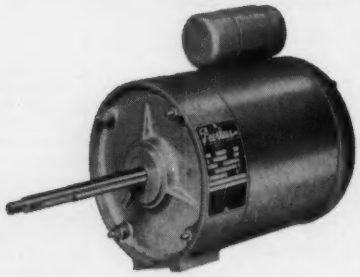
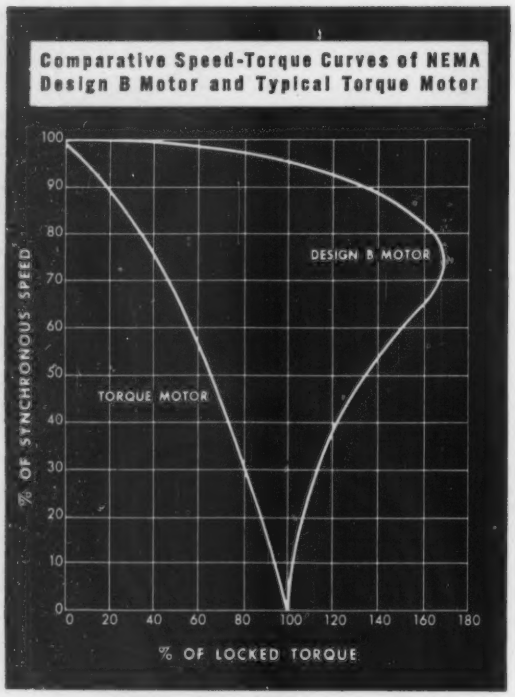


Special Flange Reversing Hoist Motor Single Phase

Comparative Speed-Torque Curves of NEMA Design B Motor and Typical Torque Motor



The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.

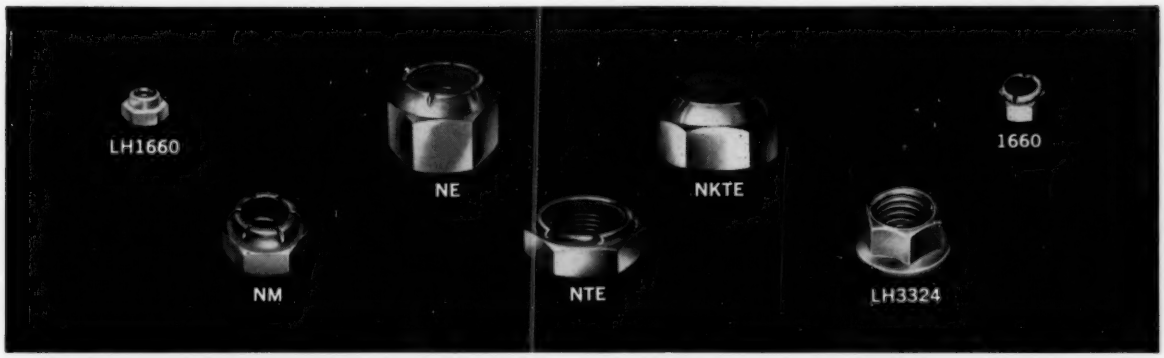
NEW TORQUE BULLETIN-This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.

Peerless Electric Division, H. K. Porter Company, Inc., Warren, Ohio

PEERLESS ELECTRIC DIVISION PORTER **H. K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

17 ESNA FASTENER SOLUTIONS FOR HUNDREDS OF ELECTRO-MECHANICAL SYSTEM APPLICATIONS

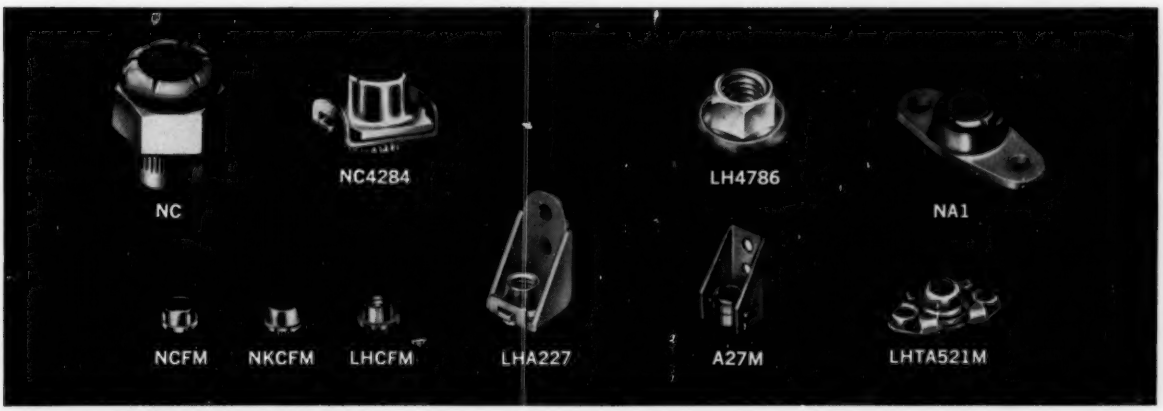


HEX TYPES

ESNA hex nut thread sizes range from a miniaturized 0-80 through standard SAE 1½"-12—and up. Designers have a choice of two types of reliable self-locking devices—depending on operational temperatures. Both types have received military approval and most parts are produced in carbon and stainless steels.

For temperatures up to 250° F., the high-reuse nylon insert type is recommended. For temperatures of 550° F. or 900° F. and higher, the all-metal offset closure provides excellent self-locking results. Nylon insert nuts can be reused a minimum of 50 times on a standard screw and still retain locking torque. Nylon will not gall bolt threads or peel cadmium from the screws to foul or short vital circuits. Its dielectric strength and volume resistivity are extremely high. Nylon caps, available in most configurations, prevent "corona" effect, seal bolt ends, protect wires from chafing on bolt edges.

All-metal nuts using ESNA's elliptically offset locking device provide excellent re-usability because of their high hardness.



CHASSIS TYPES

Clinch types fasten to chassis or console by single hole mounting. Available in standard sizes and in new miniature flush mounting types; both all-metal for 550° F. temperature and with special nylon inserts for 350° F. operating environments. Also a new floating clinch nut which gives the economy of single hole mounting plus float to compensate for minor screw or component misalignment. Both standard and miniature clinch types are available with nylon caps. For other "black box" uses there are miniature right-angle "floaters," heavy duty fixed anchors for drawer slides. There is also type LH4786, a new captive washer electric terminal nut.

The new ESNA catalog no. 960 shows the hundreds of configurations—with nylon inserts, nylon caps, or in all-metal designs—of ELASTIC STOP® nuts that are available as standard parts. Why not send for your copy today? We'll be glad to send sample nuts for testing, too. Just specify type and size. Write: Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey. Dept. S60-84.

ELASTIC STOP NUT CORPORATION OF AMERICA

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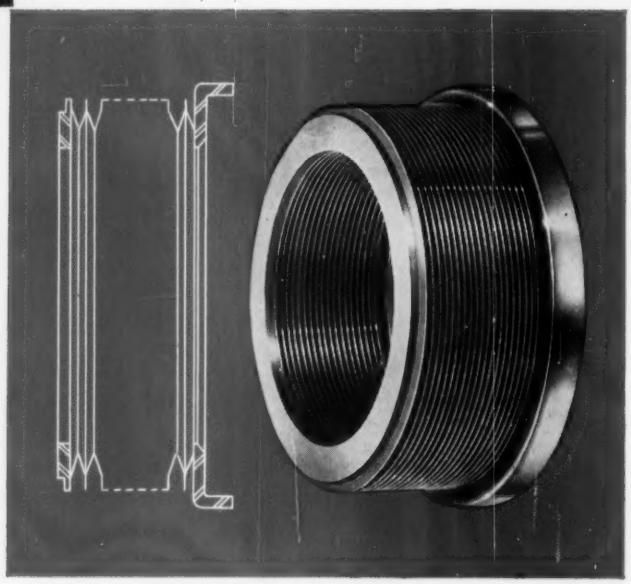
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1221 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

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